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TRANSCRIPT OF RECORD

Supreme Court of the United States

OCTOBER TERM, 1937

No. 453

GENERAL ELECTRIC COMPANY, PETITIONER,

vs.

WABASH APPLIANCE CORPORATION, ABE ADLER AND ABE M. PARKER

ON WRIT OF CERTIORARI TO THE UNITED STATES CIRCUIT COURT OF APPEALS FOR THE SECOND CIRCUIT

PETITION FOR CERTIORARI FILED SEPTEMBER 28, 1937.

CERTIORARI GRANTED NOVEMBER 8, 1937.

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N UNITED STATES DISTRICT COURT, EASTERN DISTRICT OF NEW YORK

In Equity. No. 7,723

Pacz Patent 1,410,499

GENERAL ELECTRIC COMPANY

vs.

ABASH APPLIANCE CORPORATION, ABE ADLER and ABE M. PARKER

BILL OF COMPLAINT

o the Honorable the Judges of the District Court of the United States for the Eastern District of New York:

The plaintiff for its bill of complaint says that it is informed and believes and therefore avers as stated in Paragraph I to VII, inclusive, as follows:

I. The plaintiff is a corporation organized and existing nder the laws of the State of New York having a regular nd established place of business in Schenectady, New York, nd a citizen of the United States. The defendant Wabash ppliance Corporation is a corporation organized under e laws of the State of New York, and the defendants Abe dler and Abe M. Parker are citizens of the State of New ork and said three several defendants have a regular and tablished place of business together in the Borough of rooklyn, New York, within the Eastern District of New ork, within which district as well as elsewhere in the nited States of America, the joint acts of patent infringeent hereinafter complained of have been committed.

ol. 2] II. Aladar Pacz being within the meaning of the tatutes of the United States, the first, original and sole ventor of certain improvements in Metal and its Manucture and being entitled to a patent therefor, under the rovisions of said statutes, duly applied to the Commisoner of Patents of the United States for Letters Patent r said improvements, which were not known or used by

others in this country before his invention or discovery thereof and not patented or described in any printed publication in this or any foreign country before his invention or discovery thereof or more than two years prior to his said application for patent, and not in public use or on sale in this country for more than two years prior to said application and not abandoned to the public, and said invention has not been patented in any country foreign to the United States of America on an application filed by said Pacz or his legal representatives or assigns, more than twelve months prior to said application for United States patent. The plaintiff having acquired by instrument in writing all the rights to said inventions, and all the requirements of the statutes then in force having been complied with, there were under date of March 21, 1922, duly granted to the plaintiff Letters Patent No. 1,410,499, for said improvements, whereby there was secured to the plaintiff, its legal representatives and assigns, for the term of seventeen years from March 21, 1922, the exclusive right to make, use, practice and sell said improvements, as will appear by said patent or a certified copy thereof in Court to be produced and of which profert is hereby made.

[fol. 3] III. The improvements forming the subject of said Letters Patent are of great value, importance and benefit to the public and to the plaintiff and its licensees; and the plaintiff had expended large sums of money in making said improvements available and profitable to the public, and the plaintiff and its licensees have manufactured and sold and used said improvements extensively, and are prepared to supply the whole demand which has been created therefor; and the plaintiff has marked or caused to be marked lamps embodying said invention, made and sold by the plaintiff or under its authority, by imprinting on the inclosures thereof the word "Patented" together with the day and year said Letters Patent were granted, or by imprinting on the inclosures thereof the word "Patent" together with the number of said patent.

IV. Since the grant of the said Letters Patent mentioned the plaintiff has been at all times, and is now, possessed of all the right, title and interest in said improvements and Letters Patent therefor, and has been at all times and is now entitled to all the benefits thereof.

V. Heretofore suit was brought by this plaintiff in the United States District Court for the Southern District of California, Central Division, against T. Anraku, trading as Tokyo Lamp Co., for infringement of the Pacz patent 1,410,499. A suit was also brought by the plaintiff in said Division against International Lamp Co., Inc., for infringement of said Pacz Patent. Another suit was brought by the plaintiff in said Division against Pacific Importing Company, and others, for infringement of said Pacz Patent. [fol. 4] By orders of the Court said three several suits were referred for trial to Honorable David B. Head as Special Master, and by consent of the parties the three suits were tried together. The cases having been tried by the Master and presented on pleadings and proofs, and briefs filed by counsel for both parties, a report was filed by the Master on or about November 22, 1934, reporting the patent valid, and infringed as to the claims in suit, namely, claims 25, 26 and 27, and recommending entry of decrees accordingly. Exceptions and objections to the Master's report having been filed by the defendants in said several suits, and having been brought on for hearing before the Court on oral arguments and briefs on behalf of each party, and having been considered by the Court, order of the Court was filed on or about May 3, 1935, adopting, approving and confirming the report of the Special Master, and a decree was entered in each case on or about May 14, 1935, sustaining claims 25, 26 and 27 of the Pacz Patent 1,410,499, finding infringement thereof and directing issuance of injunction, as will fully appear from said report of the Special Master, and order, and decrees of said Court or certified copies thereof in Court to be produced, and of which profert is hereby made.

VI. Within six years last past prior to the filing of this Bill of Complaint, the defendants, Wabash Appliance Corporation, Abe Adler and Abe M. Parker have within the Eastern District of New York, and elsewhere in the United States of America, unlawfully and without license of the plaintiff and in infringement of said Pacz Letters Patent [fol. 5] 1,410,499, and plaintiff's rights thereunder, jointly made, used and sold or caused to be made, used and sold incandescent electric lamps embodying or containing the improvements described and claimed in said Pacz Patent No.

1,410,499, and defendants threaten to continue said infringement, and defendants have gained great profits from said infringement, wherefore plaintiff prays that the defendants may be required to make full discovery of their gains from said infringement.

VII. But for the wrongful acts of defendants the plaintiff and its licensees and customers would now be able to make, use and sell the patented improvements of the said Letters Patent with greater profit and advantage. By such wrongful acts of defendants the plaintiff is suffering irreparable damage, unless this infringement by the defendants is restrained by order of this Honorable Court, and the plaintiff has no adequate remedy at law.

Wherefore, the Plaintiff prays:

1. For such preliminary and perpetual injunction against infringement, direct or contributory, of said Letters Patent by the defendants, their agents, attorneys, workmen and employees and officers and directors, and all persons in privity with them or any of them, as to this Court may seem just;

2. For an accounting for damages and profits due to said infringement, and that the defendants be compelled to pay over to the plaintiff the said damages as well as the profits;

[fol. 6] 3. For costs; and

4. For such other relief as to equity may seem just.

The plaintiff further prays for a writ of subpœna ad respondendum directed to the defendants, Wabash Appliance Corporation, Abe Adler and Abe M. Parker, commanding them and each of them to appear and make answer (but not under oath, an answer under oath being hereby waived) to this Bill of Complaint and to perform and abide by such orders and decrees as to this Court may seem required by the principles of equity and good conscience.

General Electric Company, by C. E. Wilson, Vice-President. (Seal.)

Attest: Wayne H. Perry, Asst. Secretary.

Howson & Howson, Solicitors for the Plaintiff, 233 Broadway, New York City, New York.

[fol. 7] *Duly sworn to by C. E. Wilson. Jurat omitted in printing.*

[fol. 8] IN UNITED STATES DISTRICT COURT

[Title omitted]

ANSWER

The defendants above named for answer to the Bill of Complaint herein, or to as much thereof as it is deemed material or necessary to be answered, and saving unto themselves the insufficiencies and imperfections therein contained, on information and belief say:

1. Answering paragraph I of the Bill of Complaint defendants Abe Adler and Abe M. Parker deny that they have a regular and established place of business severally or with each other or with anyone else in the Borough of Brooklyn, New York, within the Eastern District of New York, and all of the defendants deny that they have committed any acts of patent infringement within the Eastern District of New York or elsewhere in the United States.

2. Answering paragraph II of the Bill of Complaint, defendants deny each and every allegation therein contained except they admit having seen what purports to be [fol. 9] a copy of Pacz Patent No. 1,410,499, purporting to have been granted March 21, 1922.

3. Defendants deny each and every allegation contained in paragraph III of the Bill of Complaint.

4. Defendants are uninformed as to the matters alleged in paragraph IV of the Bill of Complaint and therefore leave plaintiff to its proofs thereof.

5. Answering paragraph V of the Bill of Complaint, defendants are uninformed save by the Bill of Complaint as to the matters therein alleged.

6. Defendants deny each and every allegation contained in paragraph- VI and VII of the Bill of Complaint.

7. Further answering the Bill of Complaint, defendants jointly and severally deny that they jointly or severally have infringed Pacz Patent No. 1,410,499, within the Eastern District of New York or elsewhere.

8. Further answering the Bill of Complaint, defendants, on information and belief, allege that the Pacz Patent No.

1,410,499, is wholly void and invalid at law and of no legal effect, for each of the following reasons, to wit:

(a) Because the alleged invention of said patent was shown and described in printed publications in the United [fol. 10] States, and countries foreign to the United States, before the alleged invention by the patentee and/or more than two years prior to the filing of the application on which the said patent issued, as follows:

United States Patents:

Edison, 436,968;
Edison, 436,969;
Burden, 446,619;
Kellner, 661,610;
Von Bolton, 817,732;
Von Bolton, 817,734;
McOuat, 869,013;
Lederer, 908,682;
Kuzel, 912,246;
Von Bolton, 927,935;
Coolidge, 963,872;
Plancon, 968,407;
Farkas, 1,008,806;
Farkas, 1,008,807;
Coolidge, 1,026,382;
Coolidge, 1,026,343;
Coolidge, 1,026,344;
Coolidge, 1,026,383;
Coolidge, 1,026,384;
Wood, 1,027,165;
Arsem, 1,034,949;
Lederer, 1,035,883;
Kuzel, 1,037,268;
Trenzen, 1,074,993;
Coolidge, 1,082,933;
Frech, 1,089,757;
Scoular, 1,104,557;
Scoular, 1,178,418;
Lederer, 1,180,264;
Thowless, 1,226,925;
[fol. 11] Kruger, 1,154,701;
Mishimoto, 1,201,611;

Schaller, 1,256,929;
Schaller, 1,256,930;
Fuller, 1,280,704;
Pacz, 1,299,017;
Meyers et al., 1,363,162;
Yunck, 1,422,019;
Pacz, 1,508,241.

British Patents:

1535/1898	18808/1909
13116/1898	23499/1909
20277/1904	1161/1911
20175A/1905	8004/1911
3213/1906	15586/1911
21513/1906	18467/1911
23335/1906	5027/1912
24179/1906	5028/1912
2123/1907	9941/1912
3174/1907	27442/1912
16530/1907	3112/1913
18053/1907	3525/1913
24707/1907	16620/1914
207/1908	10928/1916
17350/1908	
17438/1908	

Austrian Patents:

33683/1908	34416/1908

French Patents:

358,272	371,557

German Patents:

152,848	173,134
159,811	200,300
283,071	

[fol. 12] Publications:

Book entitled "Development of the Incandescent Electric Lamp" by Barnham.
Book entitled "History of the Incandescent Lamp" by Howell and Schroeder.

Book entitled "Tungsten, Treatise on Its Metallurgical Properties and Application" by Smithells.

Book entitled "Science of Metals" by Jeffries and Archer.

"The Properties of Tungsten and the Characteristics of Tungsten Lamps" by Forsythe and Worthing, published in Physical Review, Vol. 7, p. 302, of 1916.

Lenher's Translation of Moissan's "The Electric Furnace," published in 1904 by The Chemical Publishing Company of Easton, Pennsylvania.

Article "New Metallic Filament Lamps," Eclairage, Electrique, Vol. 47, pp. 209 to 212.

Publication by Weiss on "Tungsten Metal," published by Zeitschrift Fuer & Organische Chemie, 1910, pp. 279-323.

Article by Otto Kruh, "The Drawing of Tungsten Wire," August 29, 1913, published in Electrotechnik Mashinenbau, 21st year, Vol. 31, pp. 313-319 and 338-342, inclusive,

and divers other publications of which defendants are not at present advised but beg leave to add hereto, by proper amendment to this, their answer, when such information is obtained.

(b) Because the said patent discloses no patentable invention over and/or in view of the state of the art at and [fol. 13] prior to the time the alleged invention is purported to have been made, and as illustrated in the instances thereof referred to in paragraph (a) hereof.

(c) Because the matter purporting to be covered by the said patent is not a statutory subject of a patent.

(d) Because the patentee was not the first and original inventor of the matters purporting to have been patented.

(e) That for the purpose of deceiving the public, the description and specification filed in the Patent Office was made to cover less than the whole truth relative to the invention.

(f) That the description of the invention and the specification is not in such full, clear, concise and exact terms as

to enable any person skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct, and/or use the same.

(g) Because the alleged invention of said patent was publicly known to others before the alleged invention thereof by the patentee, or more than two years prior to his application for Letters Patent therefor. Defendants are not at present advised of the particulars of such prior knowledge but beg leave to add hereto by proper amendment to this, their answer, when such information is obtained.

(h) Because the alleged invention was in commercial use and/or on sale before the alleged invention thereof by the [fol. 14] said patentee, or more than two years prior to his application for Letters Patent therefor. Defendants are not at present advised of the particulars of the instances of prior commercial use and/or sale but beg leave to add hereto by proper amendment to this, their answer, when such information is obtained.

(i) Because of unreasonable delay in filing a disclaimer of invalid subject matter contained in said patent.

(j) Because of double patenting in view of Pacz Patent No. 1,299,017.

Wherefore, defendants deny that plaintiff is entitled to the relief prayed for, or to any relief, and therefore pray to be hence dismissed with their costs in this cause sustained.

Wabash Appliance Corporation, Abe Adler and Abe M. Parker; by Darby & Darby, Their Attorneys.

Darby & Darby, Attorneys for Defendants, #405 Lexington Avenue, New York, New York.
Samuel E. Darby, Jr., of Counsel.

Dated, New York, N. Y., —— —, 1935.

[fol. 15] IN UNITED STATES DISTRICT COURT, EASTERN DISTRICT OF NEW YORK.

E. 7723.

GENERAL ELECTRIC Co., Plaintiff,

vs.

WABASH APPLIANCE CORPORATION, ABE ADLER and ABE M. PARKER, Defendants.

Narrative Statement of the Evidence

Before Hon. Matthew T. Abruzzo, U. S. D. J.

Brooklyn, N. Y., June 23, 1936.

APPEARANCES

Howson & Howson, Esqs., by Hubert Howson, Esq., of Counsel, and Fish, Richardson & Neave, Esqs., by Merrell Clark, Esq., Alexander C. Neave, Esq., and John E. Anderson, Esq., of Counsel, Solicitors for Plaintiff.

Darby & Darby, Esqs., by Samuel E. Darby, Jr., Esq., and Paul Kolisch, Esq., of Counsel, Solicitors for Defendants.

OFFERS IN EVIDENCE

By Mr. Clark: I offer in evidence as Plaintiff's Exhibit No. 1 a copy of the Pacz patent No. 1,410,499, patent in suit, in which claims 25, 26 and 27 are declared upon.

(Marked Plaintiff's Exhibit 1 in evidence.)

[fol. 16] As Plaintiff's Exhibit 2 I offer in evidence the Coolidge patent No. 1,082,933, to which reference is made in the patent in suit.

(Marked Plaintiff's Exhibit 2 in evidence.)

In order that the Court may have before it the record in the California case, in order to determine what was before the Court in that case, I offer as Plaintiff's Exhibit 3 the transcript of the record in that case, and as Plaintiff's Exhibit 4 the book of exhibits in that case.

(Marked Plaintiff's Exhibits 3 and 4 in evidence, respectively.)

I should like to make a record also of the fact that a number of consent decrees have been entered under this patent. We have here certified copies of the consent decrees.

Mr. Darby: I accept your statement.

I offer in evidence as Exhibit No. 5 the list of consent decrees which have been entered under this Pacz patent.

Mr. Darby: I would like to make of record my objection to it as irrelevant and immaterial because a consent decree certainly does not carry with it any weight.

The Court: I will take it. Of course, you understand there is no jury here.

(Marked Plaintiff's Exhibit 5 in evidence.)

Mr. Clark: Then I should like to read some matters that have been stipulated between counsel:

STIPULATION AS TO CERTAIN FACTS, ETC.

First, that printed or photographic copies of patents and publications may be offered in evidence and used with the same force and effect as certified copies, subject to correction, if error shall appear;

[fol. 17] And the dates of filing appearing on patents, and the dates and places of publication appearing on publications so offered may be taken as prima facie correct but subject to correction.

Second, the incorporation of the plaintiff company and the corporate defendant company, as pleaded in the bill, may be taken as proved, and the plaintiff's title to the patent in suit as pleaded, may be taken as proved.

Third, that for more than six years past prior to the filing of the bill of complaint in this cause, the plaintiff, General Electric Company, manufactured and sold electric incandescent lamps with drawn tungsten wire filaments, assertedly under the patent in suit, and it has been the practice of said plaintiff during that time to put up all of its said incandescent lamps in individual cartons or wrappers, having printed thereon the numbers of several patents, including among others patent No. 1,410,499, a typical example of such carton or wrapper being here produced as Exhibit 6.

(Marked Plaintiff's Exhibit 6 in evidence.)

ZAY JEFFRIES, called as a witness on behalf of the plaintiff, being duly sworn, testifies as follows:

Direct examination.

By Mr. Clark:

I live in Cleveland, Ohio. I am a metallurgical engineer connected with the Incandescent Lamp Department of the General Electric Company, also consulting metallurgist for [fol. 18] the Aluminum Company of America. I am chairman of the Technical Committee at the Lamp Headquarters at Nela Park in Cleveland. I am also president of the Carboloy Company, a subsidiary of the General Electric Company.

The product of the company is composed mainly of Tungsten in the form of carbide and carbide particles are cemented together at high temperature with some other metal, such as cobalt.

I have the degree of Bachelor of Science in Mining Engineering, and degree of Metallurgical Engineer, and the honorary degree of Doctor of Engineering, all from the South Dakota School of Mines, Rapid City; I have the degree of Doctor of Science from Harvard University, majoring in metallurgy in that institution.

I taught for six years at the Case School of Applied Science. I have a list of some technical papers which I have written as follows: Lecture before the Institute of Metals of the American Institutes of Mining & Metallurgical Engineers. Howe Memorial lecture before the same institute. E. D. Campbell Memorial lecture of the American Society for Steel Treating. The so-called Thurston lecture before the American Society of Mechanical Engineers.

I have been Chairman of the Non-Ferrous Metals Division of the Socitey of Automotive Engineers and the A. I. M. M. E., and president of the American Society for Steel Treating. In 1927 I received the James Douglas Gold Medal from the A. I. M. M. E. for distinguished service in nonferrous metallurgy. I have published some 35 or 40 tech-[fol. 19] nical papers and am co-author with R. S. Archer of the Science of Metals, and co-author with Edwards and Frary of the Aluminum Industry. I have written a chapter on alloys for the new Encyclopedia Brittanica.

I first became associated with the General Electric Company in 1914. I began as special investigator on Tungsten

at the Cleveland Wire Works of the National Lamp Department of the General Electric Company. I was still teaching at Case at that time and spent the summer of 1914 at that work largely on Tungsten. When school began in the Fall of 1914, I continued to work part time for the General Electric Co., and have been continuing with that type of work ever since.

In 1922 or thereabouts I gave additional time and effort to the Lamp Department, having left my teaching position in 1917.

About 1922 or 1923 there was formed at Cleveland the Research & Development Committee, of which I was made vice-chairman. A little later two divisions of the General Electric Company manufacturing and selling incandescent lamps combined into one division. The two earlier divisions were the National Division and the Edison Division. They merged into one division, now known as the Incandescent Lamp Department of the General Electric Company. And then in 1927 I became chairman of the Technical Committee of the combined Lamp Divisions. I still hold that position.

The following is briefly the historical development of the Incandescent Lamps: The lamps prior to 1906, were mostly of the carbon filament type, although a few metal filament [fol. 20] lamps, such as the osmium lamp and the tantalum lamp had been made and sold prior to 1906.

At about that time the Tungsten filament was developed by Just and Hanaman, and it was considerably more efficient than the carbon filament or either of the prior metal filament lamps.

The first form of Tungsten filament was a pressed or squirted filament. I shall describe just in general how that was made, so we will know what is meant by a squirted or pressed filament. Tungsten powder was first produced, and it was mixed with a carbonacious material, such as starch, to form a paste. This paste was put in a cylinder and extruded through a small opening, the extruded or squirted part being the size desired for subsequent use as a lamp filament.

This squirted filament was shaped in the form of hairpins and laid out in that form on a cardboard and then when the paste dried the loops were in the shape of a hair pin or approximately that shape.

These loops were then dried in a furnace at a relatively high temperature, after which the material became electric-

ally conducting. Then the loops were taken separately and put into clamps and a hydrogen atmosphere was maintained around them and an electric current was passed through. In this way, the binder material was pretty much driven out, and the filament was heated to such a high temperature that it was consolidated.

If some carbon remained, it was taken out by means of wetting or moistening the hydrogen atmosphere surround- [fol. 21] ing the filament, the carbon then being taken out in the form of carbon dioxide.

These fine filaments are representative of the squirted filaments about which I have just been testifying.

Mr. Clark: I now offer the filaments in evidence as a plaintiff's exhibit.

(The above filaments contained in a box were received and marked Plaintiff's Exhibit 7 in evidence.)

This lamp I recognize as a lamp originally equipped with a pressed Tungsten filament.

Mr. Clark: I offer this lamp in evidence.

(Received in evidence and marked Plaintiff's Exhibit 8.)

This lamp is typical of the carbon filament construction.

Mr. Clark: I offer that lamp in evidence.

(Marked Plaintiff's Exhibit 9 in evidence.)

The Court: Will you put those lamps on that panel board now so that I may see them lighted?

The Witness: Yes, your Honor. (Witness demonstrates.)

Mr. Clark: Pressed filament lamps—the filament is broken, your Honor.

The Witness: I think I have one, but it is 30 volts, and it would burn out very quickly on this current. I have a [fol. 22] thirty volt lamp and it will flash before it burns out.

The carbon lamp is 110 volts. I might say that the distinguishing feature about this squirted tungsten lamp is that these tungsten hairpins are mounted separately. Each hairpin represents a unit so that when the current flows it is in series through the three hairpins, and the support connections must be such that the current is connected from one hairpin to another.

The later wire type Tungsten filaments are of different construction. The filament is one piece instead of three and the whole length of the filament is on the support and the supports do not have to form a connection. If this 30 volt lamp burns at all, it will just flash up quickly and out again. There (indicating) it has burned out now. Before burning out it showed a typical construction of the old squirted filament lamp.

The Court: It was a whiter light, too, wasn't it, Doctor?
The Witness: Yes, whiter than the carbon lamp.

The objection to this squirted form of filament was that the filament was too weak and fragile to make the most satisfactory lamps and furthermore the filaments could not be readily made in long lengths, nor could they be made with accurate control of finished diameter. The main difficulty was corrected when the drawn Tungsten wire was introduced. This wire was strong and could be made in long lengths, and could be made to accurate size.
[fol. 23] That was the process described in the Coolidge patent that has been offered in evidence.

Briefly, ductile Tungsten filament is made in accordance with the Coolidge process as follows: The first Tungsten powder is produced very much the same as in the squirting process, except that the powder itself is made considerably coarser. Then the powder is pressed into slugs. The slugs are then baked in a hydrogen atmosphere at a temperature of from 1200 to 1400 degrees centigrade until they conduct electricity. The baking also makes the slugs somewhat stronger and easier to handle. The slug is then put between two electrodes in what is called a treating bottle in which is maintained a hydrogen atmosphere and an electric current is passed through the slug until the temperature is reached nearly up to the melting point of Tungsten. Under those conditions the pressed powder is sintered into a solid coherent mass of Tungsten, which is then cooled and removed and is ready to be mechanically worked.

This is a bar typical of the Tungsten slug after treating or sintering and just before the mechanical working process.

Mr. Clark: I offer this in evidence as a plaintiff's exhibit.

(Marked Plaintiff's Exhibit 10 in evidence.)

These progressively smaller rods, three of which are bundled together, represent successive stages in the mechanical working operation which is known as a swaging operation. Swaging is done at a very high temperature and [fol. 24] the operation is one which is accomplished by means of two hammer die blocks which are actuated by centrifugal force on the one hand in the swaging machine and rollers on the other. Centrifugal force moves the dies apart and the rollers push them together again, so that as the Tungsten rod is pushed between the dies slowly, the dies are moved to and from the axis very rapidly, thus working the Tungsten in such a manner that the length of the rod is increased and the diameter is decreased.

That was the last exhibit, that is before the swaging. These represent short pieces of swaged rod at different diameters.

Mr. Clark: I offer these in evidence as one exhibit, the three progressively smaller rods which the witness has just been referring to.

(Marked Plaintiff's Exhibit 11 in evidence.)

Swaging for many years was carried down to 30 thousandths of an inch diameter. At the present time, the swaging is not carried so far, but for many years the greater part of the working of the larger pieces was done by swaging.

After your swaging operation, the final character of the operation which produces the filaments is drawing. The swaged rod is drawn hot through a series of dies, gradually reducing diameters to any desired finished size. The fine wire so produced is the strongest material known. It sometimes has a tensile strength as high as 650,000 pounds per square inch. The filament is ductile and can be coiled [fol. 25] and bent and can be handled in the manufacturing process without danger of breaking.

I have here a spool of this fine filament. I shall start that unwinding and exhibit to the Court what this long filament is that is produced by the process I have just described.

(The witness demonstrates to Court.)

The fact that this drawn wire was made in long lengths greatly facilitated lamp manufacture. The filaments could

be cut in such manner that the lamp could be made of one piece instead of several pieces, as was the practice with the squirted filaments. Then, too, the long length made possible automatic and semi-automatic lamp manufacture.

I shall now discuss the question of the matter of offsetting. In the Coolidge patent which has been offered in evidence, No. 1,082,933, this subject is referred to, for example, at page 2, lines 13 to 23, as follows:

"When this crystallization becomes excessive, the crystals may, in the case of a filament become so large as to extend across the entire section of the filament and thereupon the sections may move laterally upon each other and produce the condition known as offsetting. I shall hereinafter describe more in detail the special method which I employ for minimizing the loss in ductility and for preventing this offsetting effect."

I shall explain a little later how Coolidge accomplished this, but before doing so, I wish to explain a little more in detail and with the aid, of this greatly enlarged photo- [fol. 26] graph just what offsetting is.

Mr. Clark: I offer this photograph in evidence as Plaintiff's Exhibit 12.

(Marked Plaintiff's Exhibit 12 in evidence.)

I will offer in evidence also the spool of wire to which the witness has just been referring, as Plaintiff's Exhibit 13.

(Marked Plaintiff's Exhibit 13 in evidence.)

The term "offsetting" is used in connection with the lateral displacement of one section of a filament with reference to adjacent sections. This enlarged photograph, Plaintiff's Exhibit 12, shows the effect at at least four places—probably five. But at each place, it will be noted that there is a marking somewhat analogous to a joint in a bamboo rod. Those markings are known to be the joints between different crystals. So that this may be said to be composed of a group of Tungsten crystals joined together at the places where the markings appear, and each marking then would be referred to as a grain boundary or crystal boundary. So it is clear that the slipping of one section

with reference to another has taken place along or on those grain boundaries. It will be noted also that the boundaries had a tendency to be substantially perpendicular to the axis of the filament itself.

That drawing illustrates what Coolidge is referring to, for example, when he said the crystals were so large as to extend across the entire section of the filament and there- [fol. 27] upon the sections may move laterally upon each other and produce the condition known as offsetting. I should have stated that this occurs only when the filament is burned with alternating current.

Offsetting took place in the squirted Tungsten wire as well as the pure drawn Tungsten wire. I don't know what forces are present that cause one section to slip with reference to the other. But I do know it occurs under alternating current when the grains do extend across the filament and the boundaries are at substantially right-angles to the axis of the filament.

Offsetting was recognized as a problem in the art by others than Coolidge prior to Pacz, it was a well-known problem. In that connection, I would like to refer for example, to the Myers and Hall patent No. 1,363,162, and particularly to the portion beginning at page 1, line 56, which reads as follows:

"Such crystals seem to increase in size in much the same manner as crystals formed in liquid solutions and if the crystals become large enough to extend almost or entirely across the filament, adjacent crystals tend to slip along their cleavage planes thereby giving the filament the offset of faulted appearance above referred to."

That is another statement of the same thing that is referred to in the Coolidge patent from which I read.

Mr. Clark: I offer this Myers & Hall patent in evidence. [fol. 28] Mr. Darby: I object to that, if the Court pleases. This patent is not admissible in this case, apparently it is being used for the support of the witness' opinion as to the effect of offsetting and that has already been put in the record and it has been read into the record and the witness agrees with it.

Mr. Clark: We are just painting the picture of what the art was as Pacz found it, your Honor.

The Court: I will take it, the objection is overruled. He would probably get it in on rebuttal anyhow, Mr. Darby.

(Received and marked Plaintiff's Exhibit 14.)

The objection to offsetting in a filament shortens the life of a filament on the one hand and makes it much more brittle on the other. That is as these adjacent sections move relatively to one another, the cross-sectional area at the point of contact is gradually reduced and when the filament is burning the temperature at that spot is increased and that hastens the burn out. It happens also that the grain boundaries are the places of mechanical weakness in a filament when it is cold, and the places where the offsetting has already taken place represent the places with mechanical weakness when the filament is cold, and in fact, a structure which promotes offsetting or permits offsetting is one which also corresponds to a weakness mechanically when the filament is cold.

The slipping or offsetting first occurs after long burning and, of course, when the filament is hot and when it is being [fol. 29] heated by alternating current.

Returning now to the Coolidge patent, Coolidge prevented offsetting by incorporating a foreign material into the Tungsten in the form of minute particles which particles would dispose themselves between the grains and inhibit the free growth of the grains so that he cured offsetting, the offsetting phenomena by keeping the grains in the filament small, in other words, by inhibiting the grain growth.

Grain growth refers to the absorption of certain grains by others when the filament is heated to a high temperature.

After the filament is drawn the original grains which were present in the slug, which were equiaxed in shape, had been drawn out into minute fibres by a drawing process. When the filament is heated to a temperature much above 1200 degrees Centigrade, these fibres form into minute crystals or grains, and then as the temperature is increased, the grains have a tendency to grow—that is, certain of the grains grow at the expense of the other grains. Eventually, in some cases, certain of the crystals become so large that they extend across the entire diameter of the filament. And Coolidge did propose and did prevent such growth. Coolidge incorporated this foreign material, thoria on the one hand, or the materials of the Hessian or Battersea

crucible on the other hand in such a way as to keep the grains relatively fine, even for a thousand hours of burning. That is, the grains in the ultimate filament. I know of only one other than Coolidge's for inhibiting the growth of the grains that was proposed for eliminating offsetting, and [fol. 30] that was a method of producing the filament in the form of one single crystal so that there would be no grain boundaries at all.

Q. 61. To what extent, if any, was that successful?
A. It was not a practical method.

In connection with the Coolidge patent, particularly his use of thoriated Tungsten to inhibit grain growth, I refer to a chart entitled "Thoriated Tungsten," and I draw attention first to the upper and lower photographs on the left-hand side. Those are photographs of a polished section of a number of adjacent turns of spirally coiled filament, filaments such as shown in the two central photographs, magnified 200 diameters. Now, the coil filament shown in the two photographs in the center, left, of this chart, are magnified ten diameters. A section of the coil is mounted in a special way so that it is anchored to, say, a brass block, and then copper or cobalt is electrolytically deposited around the coil. Then the whole mass is polished on a polishing machine until the sections of the coil begin to show under the microscope much as the flattened portion of this coil of copper wire which I hold in my hand.

Mr. Clark: I offer this coil of copper wire in evidence as Plaintiff's Exhibit 15.

(Marked Plaintiff's Exhibit 15 in evidence.)

The polished section is etched by chemical attack so as to make the separate grains show when the section is examined under the microscope. So the top photograph is taken from a filament which has been flash-aged only. By [fol. 31] flashaging I mean that the filament has merely been lighted up for a couple of minutes by gradually increasing voltages until a final voltage of about 115 per cent of normal is reached; but then after the two minutes heating it will be seen that the filament is composed of a large number of relatively small grains.

The photograph at the bottom is the same type of filament after burning 115 hours at normal voltage.

The grains are larger than in the photograph at the top but still quite small after 115 hours of burning.

I think it might be worth while just to contrast the grain size in this exhibit to which I have been referring with that of Plaintiff's Exhibit 12, in connection with which I explained offsetting. In Plaintiff's Exhibit 12 the crystals are so large that they extend across the entire section of the filament, whereas in the example of the Coolidge filament which I have just referred to, there are no grains large enough to extend across the entire filament diameter and hence there are no planes where offsetting could occur in the Coolidge filament.

Mr. Clark: I offer in evidence as Plaintiff's Exhibit No. 16, the chart entitled, "Thoriated Tungsten."

(Marked Plaintiff's Exhibit 16 in evidence.)

Referring to this same chart, Plaintiff's Exhibit 16, it will be noted that the filament of the lamps illustrated in that chart is a coil filament. The incandescent Tungsten filaments now in general use are largely of the same coil [fol. 32] type. Coil filaments were used to a limited extent prior to the introduction of the Langmuir or gas-filled lamp, but the introduction of the Langmuir lamp created a great demand for the use of coil filaments.

The extensive use of the gas-filled lamp not only brought about the use of the coil filaments in the gas-filled lamps, but also eventually the use of coil filaments in most of the vacuum lamps that are made today.

With the use of this same chart, Plaintiff's Exhibit 16, I shall explain what is meant by the term "sagging" as applied to incandescent lamp filament. On the right of this chart, Plaintiff's Exhibit 16, are two pictures of a lamp. The upper one shows a lamp after flash aging only, the flash aging having been done with the base of the lamp up. During the flash aging the filament took a set as can be seen by its shape because the coils go upward. When it was burned the coils bowed downward.

The photograph of the lamp in the lower part of this chart was taken after 115 hours burning in the base down position, at normal voltage. It can be seen that the coil now bows down and the changed position is a result of the sagging of the filament.

The two photographs in the center left are 10 power magnifications of sections of the lamps on the right. It will be noted in the 10 power photograph that the adjacent turns of the coil have been somewhat separated in the lamp which has been burned 115 hours as compared with the one which has been flash aged only.

Incidentally the same effect can be seen in the two micro-
[fol. 33] graphs or microphotographs at the upper and lower part of the chart because the coils were mounted in such a way as not to put any additional strain on the turns, and it can be seen that the turns are farther apart in the lower photograph than they are in this upper photograph and that spreading of the turns of the coil is another evidence of sagging.

Q. 72. Would you say that the sagging illustrated on this chart was typical of what is to be expected from the Coolidge thoriated Tungsten filament?

A. Yes, it is typical and that is only the amount of sagging which occurs in eleven or twelve per cent. of the life of the lamp, because such a lamp should live around 1000 hours, and that is only 115 hours; the sagging continues, I may say, practically throughout life.

I have here a lamp equipped with a Coolidge thoriated Tungsten filament by which I could demonstrate the sagging propensities.

The Court: That upper one on the left and the lower one are pretty much alike to the naked eye, are they not?

The Witness: Yes.

The Court: As you look at it with the naked eye, you don't see very much difference?

Mr. Clark: That is right, your Honor. But both of them illustrate the small crystals as compared with the coarse crystals extending across.

The Court: Perhaps under a microscope there would be a different scene.

Mr. Clark: Yes.

The Witness: I have here a lamp equipped with thori-
[fol. 34] ated Tungsten filament. It is the same construction as is shown in one of the drawings of the Pacz patent in suit.

The Court: Is this lamp a Coolidge system (indicating)?

The Witness: Yes.

The Court: And not the Pacz system?

The Witness: That is right.

I shall specify generally the figures in the patent in suit that was used for the construction. Figure 2. It will be noted that the filament is mounted in what is sometimes termed a saw tooth construction, and there are four so-called teeth in this filament mounting. I will mount the filament in this holder and in such a position that the lamp is burning horizontally and if the filament sags the change of position of at least two of the saw teeth should be noted.

Mr. Darby: That has not been lighted yet.

The Witness: It has been flash aged only.

Mr. Darby: Is this a commercial structure or was it made for this purpose only?

The Witness: It is not made commercially at the present time, but the lamp was made commercially and sold in large numbers many years ago.

The Court: This is the Coolidge one which was improved by Pacz?

Mr. Clark: That is right, your Honor.

The Court: And you are trying to illustrate what it was and what this Pacz patent did to improve it?

[fol. 35] Mr. Clark: Yes, your Honor.

Mr. Darby: But this lamp is not one of the standard commercial lamps.

The Witness: This lamp was made up about three years ago under my direction.

Mr. Darby: This very lamp?

The Witness: Yes.

Mr. Darby: And that was in connection with the trial out in California?

The Witness: Yes, it was. I may say that we make these lamps at the present time regularly for the sag testing of filaments.

Mr. Darby: Not for commercial use.

The Witness: Not for sale, no, sir.

Mr. Darby: Wait just a minute, Doctor. I want to get my other glasses.

Now, watch it carefully, because you may see the motion. When the current was turned on, the two bottom saw-teeth pointed definitely upward. Right now one of them points definitely downward, and the other is about horizontal.

After two minutes the saw-tooth which had sagged the most is at an angle of about 40 degrees downward from the horizontal.

Q. Do you want to turn that off now, or do you want to leave it on?

A. I think this is sufficient to illustrate the way in which the thoriated filament sags.

Q. Have you another of those lamps which is unburned and which we could compare with that, after turning the current off.

A. No, but I have samples of the same type of lamp after burning two and one-half hours.

The Court: The light comes from those four prongs?
[fol. 36] The Witness: Yes.

—. ——.

The Witness: This lamp has been burned in the horizontal position three minutes, and it can be seen that the one saw-tooth which projected definitely upward before the current was turned on, now projects downward at an angle of almost 45 degrees.

Mr. Clark: I offer this lamp in evidence as Plaintiff's Exhibit 17.

(Marked Plaintiff's Exhibit 17 in evidence.)

Sagging has many objections. Sometimes the filaments have been known to sag so far that they touched the glass of the inner wall of the bulb and thus caused the end of life of the particular lamps in which this occurred.

Also it is desirable to keep filaments in one position as much as possible for many lamp purposes.

The palliative for sagging wire is to use a large number of supports; and each support, where it touches the filament, cools it and thus detracts from the electrical efficiency, so it is possible to make more efficient lamps with fewer supports.

In gas-filled lamps, in particular, when the coils spread apart, the gas flows in between the coils and unduly cools the filament, thus reducing efficiency.

Sagging is particularly bad in a coiled filament as opposed to the straight filament. Naturally the load which is put on the filament and which causes sag is the force of gravity. This force is very high in Tungsten because Tungsten is practically as heavy as gold.

[fol. 37] Then when the filament is coiled, the weight is increased between supports and the force needed to open up

the coils is much less than the force needed to actually stretch the straight filament.

So in any kind of a coiled filament the non-sag property is very valuable.

This sagging was a definite problem in the art prior to Pacz. And became more acute, as I have explained, with the introduction of the coiled filament.

The Court: What do you mean by gas-filled lamps?

Up until 1913 all lamps had been so-called vacuum lamps. The carbon lamp is a lamp in which the carbon filament operated in vacuum inside of a bulb, the osmium lamp the same, the tantalum the same, and the Tungsten lamp up to about 1913. About that time Dr. Langmuir invented so-called gas-filled lamps in which he found that if he could keep the filament short enough he could operate at much higher temperature with an inert gas like nitrogen or argon surrounding the filament than he could in a vacuum.

The evaporation rate was slower with the gas than it was in the vacuum. The way that he got the short filament was to make these closely wound spirals and he found that the heat loss was proportional to the length of the coil rather than the length of the wire in the coil and therefore he was able, for the first time, to take advantage of the lower evaporation rate of the Tungsten in the inert gas, to gain light efficiency.

[fol. 38] Inside of that bulb is a mixture of argon and nitrogen. It is 86 per cent argon and the balance nitrogen. That is what we mean by a gas filled lamp.

Coolidge taught nothing with regard to the elimination of sagging. As a matter of fact, I have just illustrated what the Coolidge filament does in regard to sagging. Coolidge solved the offsetting problem, but he solved it in such a way that the resulting filament sagged and sagged quite badly.

I now refer to the Pacz patent in suit and call attention to the portion of the specification beginning at page 1, line 9, wherein it is stated:

"The object of my invention is to produce Tungsten metal which will retain to a much higher degree than heretofore its original properties, after being subjected to high temperatures. In the case of incandescent lamp filaments the high temperatures at which they are run have caused them to elongate and sag between their supports. This is espe-

cially noticeable in coiled filaments and in gas-filled lamps this tends to reduce the efficiency of the lamp on account of the increased cooling effect on the filament. By means of my invention the sagging is substantially eliminated and 'offsetting' of the filament is substantially prevented, during a normal or commercial useful life of the lamp."

Then I will omit for a moment the reference made to process, and begin at the bottom of the same column, at line 54, wherein it is stated,

[fol. 39] "The ingot of Tungsten thus produced, whether it be due to the fact that the grains have not reached the equilibrium grain size or to other causes is particularly susceptible to grain growth during subsequent heat treatments. The probable reason why filaments made according to my invention do not sag is that the structure is comparatively coarse grained."

I shall now explain as much as is known as to the relation between a coarse grain, to which the patent here refers and the non-sagging characteristic of his wire. It is now known that the extent of sag depends upon the grain size, that large crystals inhibit sag and small crystals promote sag. So that the statement in the Pacz patent that the reason his filaments do not sag is due to the comparatively coarse grain structure, is a correct statement, and now known universally to be true.

By the same token, the sagging propensities of the Coolidge thoriated Tungsten filament with its very fine grain are attributable to the fact that it is a fine grain filament.

Now, continuing with the specification. It states: "The coarse grained filament produced by means of my invention does not 'offset' so as to cut short the life of the lamp appreciably."

I understand by that that he is proposing to produce a filament which is both comparatively coarse grained and non-offsetting which was a new combination in the art at the time that this disclosure was made; that is prior to Pacz, if one were to say that the filament were coarse grained, it [fol. 40] would merely be another way of saying that it would surely offset. So Pacz is showing here a particular kind of a coarse grain filament that does not offset.

Necessarily that kind would be one in which the grain boundaries were of such a nature that they inhibited the slipping action which must occur if a filament is to show the offset phenomena.

That is as contrasted with the grain boundaries shown in Plaintiff's Exhibit 12. Either that the grain boundary position would be very much different from those shown in Plaintiff's Exhibit 12 or that the microscopic roughness of the grain boundary would be much greater than that of the prior art filaments.

Q. 90. Now, refer to the patent again and on lines 79 to 83, he says, "In order to comply fully with the requirements of the patent statute, I will now describe one method or process of embodying my invention and also modifications thereof."

Since the process claims are not in suit, I will not ask you to go into details with regard to the process described. You are familiar with that process, though, aren't you?

A. Yes.

Q. 91. Will you state whether that process in fact produces a filament of the character described by you as one having grains of such size and contour as to prevent substantial sagging or offsetting?

A. It does.

Q. 92. Has the process as set forth in the Pacz patent been used commercially by the General Electric Company in the production of non-sag, non-offsetting wire?

A. Yes.

Q. 93. For how many years, do you know?

A. It was used four or five years just as described in the [fol. 41] patent. And then later it was used with a slight modification to effect more definite control, but in all essential details the same as described and outlined in the patent itself. The modification was a fairly obvious one, I should say, in that the Pacz process, as he described it, depended upon the retention of a small amount of certain salts, like potassium and sodium and silica, in the oxide after incomplete washing. The modification of which I speak is one in which the washing was done more completely and then the oxide analyzed and then additional salts of the same kind were added to bring the total amount up to a certain figure, and then the process was carried on quite exactly as described in the patent from that point on.

Q. 94. Any difference in the grain structure of the filament depending upon which of these processes was used?

A. No, there was better control, but the main body of the filaments made under the old regular Pacz method had exactly the same characteristics as the filaments which are being made today.

Q. 95. Did you state when this change was made?

A. About 1921, as I recall it.

Q. 96. And the old way was begun when?

A. About 1915.

Q. 97. What name was given by Pacz to the lamp produced in accordance with his patent?

A. 218.

Q. 98. Why, do you know?

A. According to his own story, because that represented his 218th experiment in connection with his investigation of Tungsten.

He was in the employ of the General Electric Company at the time he made this improvement.

[fol. 42] I now refer to a chart entitled "Pacz 218," and shall describe what is shown on that chart and compare it with the corresponding showing on the chart, Plaintiff's Exhibit 16, entitled "Thoriated Tungsten."

Mr. Clark: I ask that the chart be marked Plaintiff's Exhibit 18.

(Marked Plaintiff's Exhibit 18 in evidence.)

A. This 218 chart shows a companion set of exhibits to the ones shown in chart, Plaintiff's Exhibit 16. The lamps are the same kind of lamps except that instead of thoriated Tungsten coils, they contain Pacz 218 coils.

The top lamp is a picture after flash-aging only. To the right of it is a crystalline structure after flash-aging only. And they can be contrasted with the crystalline structure of the thoriated tungsten shown on the other chart.

The latter is fine-grained and the Pacz 218 is coarse-grained. There are only a few grain boundaries shown. Most of the crystals extend across the full diameter of the filament and it can be seen that the junction between adjacent crystals is not conducive to easy slipping and hence not conducive to offsetting.

This micrograph at the top of the chart is also magnified 200 diameters. Below it is a ten power picture of the coil showing that the filament of the lamp is actually a coiled filament and also indicating that the loop is fairly straight after flash-aging.

At the bottom of the page are pictures of the same lamps, or companion lamps, after 115 hours burning.

[fol. 43] The lamp pictures are the same and taken from the same position, that is, a photograph was taken of the lamp shown at the top of the page, and then after 115 hours burning another photograph was taken of the same lamp.

Now, the pictures on the right are companion lamps. It will be noted in the ten-power picture opposite the lamp which had burned 115 hours, that the coil has shown no perceptible sag after 115 hours.

My experience is that the coil will show no perceptible sag even after 1000 hours, or up until the end of life.

The micrograph at the bottom of the page shows a section of the coil after burning 115 hours and its structure, for all practical purposes is the same as after the flash aging. It is one of the characteristics of the patent—of Pacz 218 filament that it assumes almost its final grain structure very quickly when the lamp is lighted up. That is after the grain structure reaches that shown at the top of the page, there is not much more to be done in the way of grain growth so that if one were to reverse the two pictures, top and bottom, the interpretation of the test would not be changed in any way.

These grain structures shown at the top and bottom of this Pacz 218 chart, Plaintiff's Exhibit 18, are typical of what is produced by the carrying out of the process of the Pacz patent.

I shall compare the large crystals in the Pacz 218 filament illustrated on Exhibit 18, with the large crystals of Plaintiff's Exhibit 12. There is a difference in the length of the crystals, the Pacz crystals being shown longer than those shown in Plaintiff's Exhibit 12, but the main difference [fol. 44] is in the disposition of the grain boundaries. It will be seen that the tendency of the grain boundaries in Plaintiff's Exhibit 12 is to go straight across the filament or nearly perpendicular to the axis, whereas the tendency in the Pacz filament is for the grain boundaries to angle across or be irregular and in fact to avoid the perpendicular position for some reason or another.

I show another chart which has on the same sheet both illustrations of the thoriated Tungsten filament and the Pacz 218 filament.

Mr. Clark: I now offer this chart in evidence as a Plaintiff's Exhibit.

(Marked Plaintiff's Exhibit 19 in evidence.)

Q. 104. Will you please explain this chart and what it shows? First, since you have not yet referred to any illustrations of the fi*al*ment in the fibrous stage, you might state what these curious things at the top of the chart are?

A. I did say earlier that when the Tungsten wire was drawn it had the fibrous structure, and that that fibrous structure was destroyed by the heat when the filament was lighted, but the coil is mounted at its two ends in metal clamps, which clamps are relatively large as compared with the diameter of the filament and never reach a temperature high enough to destroy the fibre in the Tungsten during the burning operation.

Therefore, when a lamp which has been burned is broken and the filament is examined, if the section in the clamp is polished and etched, it still shows the coils having the fibrous structure.

So the two pictures at the top of this chart show the [fol. 45] fibrous nature of the structure of the Tungsten filament which has been in the clamp and, therefore, kept too cold for the fibrous structure to be destroyed.

In that particular respect there is no particular difference between the thoriated Tungsten and the Pacz 218; they look alike in structure. On close examination one could find, at high powers, some of the thoria fibres in one and not in the other, but at 200 diameters they look alike.

This chart indicates combinations of sagging tendencies and structures of the thoriated Tungsten and the Pacz 218. In lamps, such as I have just tested in court, on the left is a series relating to thoriated Tungsten. The upper one as mentioned, shows fibrous structure in the cold clamp. The next one below is a photograph of a lamp after flash-aging only, and just before the sag test. Then the one below that on the left is the same lamp after burning two and one-half hours. It can be seen that the saw-teeth have sagged down during the two and a half hours burning.

The micrograph at the bottom of the page on the left shows the crystalline structure of the thoriated Tungsten after two and one half hours burning, and it shows the typical fine-grained structure of the Coolidge filament.

On the right are the same, or companion photographs of tests in which Pacz 218 filament has been substituted for the Coolidge thoriated Tungsten filament.

The fibrous structure as mentioned in the cold clamp looks the same as the fibrous structure of the thoriated Tungsten lamp.

[fol. 46] After flash-aging the position of the filament looks very much the same as does the thoriated Tungsten filament after flash-aging. But after two and one half hours burning the lamp with the Pacz 218 filament shows practically no change in position of the saw-teeth. And the grain structure of this filament after two and a half hours burning is shown magnified 200 diameters at the bottom right of the chart.

This structure again is a typical Pacz 218 structure, with crystals extending across the full diameter of the filament and where the boundaries occur they are of such a nature and so disposed that offsetting could not take place at those crystal junctions.

The change from the fibrous condition shown in the first photograph to the crystalline condition with the small grains, as shown on this exhibit of thoriated tungsten, is the result of Coolidge's incorporation of the thoria during the production of the wire. If the thoria were not present the grains would be larger in the wire on the left. The presence of the thoria keeps grain growth down and keeps the grains relatively small. But there is growth nevertheless throughout the whole life of the lamp, that is, those grains continue to grow even at 2,000 hours. But not to such an extent as to extend anywheres near across the filament, in any reasonable length of time. Sometimes a few crystals towards the end of life do extend across the full diameter. On the other hand, the different effect evidenced by comparing the upper photograph of Pacz 218, and the lower photograph, where the grains have grown large and assumed these ir-[fol. 47] regular contours, which I have said prevent offsetting, is the result of previous treatment given to the material. Both Coolidge and Pacz use Tungsten. Coolidge uses thoria to prevent grain growth, and Pacz uses an alka-

line silicate at an early stage in the treatment of Tungsten oxide in order to promote crystal growth.

I have already demonstrated the sagging characteristics of a thoriated Tungsten filament lamp. I shall now, by means of a demonstration contrast the sagging characteristics of a thoriated Tungsten filament lamp and the Pacz 218 filament lamp.

I have here a lamp which is a companion to the one which was tested a little while ago, except that the filament is Pacz 218 instead of the thoriated filament.

The Court: This is one in commercial use now.
The Witness: Yes.
The Court: The one you sold five million of.
The Witness: That is correct.

This stays the same hour after hour and day after day. If it is desired to watch it for three minutes we could set it down on the floor and let it burn for the rest of the session.

The Court: Well, we will take it for three minutes and see what effect it has.
Mr. Darby: Mr. Clark, have you any objection to my asking the witness a few questions during this interval?
Mr. Clark: No.

[fol. 48] By Mr. Darby:

Q. 110. Is this a commercial form of lamp or is this made likewise especially for either this trial or the one in California?

A. It is made especially for sagging tests of filaments. This particular lamp was a commercial 100 watt lamp for several years after the introduction of the Pacz filament.

Q. 111. This particular lamp here in the court room was made——

A. Made by me especially for the California suit.

Q. 112. Was it used in the California suit?

A. A companion lamp was used in the California suit.

The Court: Do you make the commercial ones for sale any differently than you made this one?

The Witness: Yes, we mount the filaments in a small ring instead of saw-tooth—in the form of a horse-shoe in place of the saw-tooth construction. The material is the same;

standard material just as the others in this lamp that I am demonstrating now.

The Court: The only difference is the shape of the filament?

The Witness: The shape of the mounting.

The Court: Does that make any difference in the use of the lamp?

The Witness: No, it is cheaper to manufacture in the form of a horse-shoe.

The Court: And you made this saw-tooth one with the [fol. 49] special idea in mind to show whether it stays in position or sags?

The Witness: Yes.

The Court: Would the horse-shoe one show the same thing?

The Witness: Yes. Except that it takes hours to show what this would show in two or three minutes.

The Court: Because of its shape only and not because of its material?

The Witness: That is correct. This is a lamp that has a cantilever construction whereas the other would be a simple beam.

Q. 113. And this you say will show nothing after hours of burning?

A. This will show no sagging because it is a good grade of 218 filament.

The Court: I wanted to be sure that the one we are looking at now is the same as the standard commercial one on the market. He says that it is a little better material.

The Witness: This is standard filament material.

The Court: Well, when you were asked if this would sag after hours, you said no?

The Witness: That is correct.

The Court: Well, maybe you mislead me. What did you say about the material in this one not sagging?

The Witness: This material, with this particular construction will go on hour after hour with the—with substantially no sagging. The sag in this construction is meas- [fol. 50] ured in practice in a special device, so that after many hours of burning, it will detect the motion of only one degree. After three minutes there is no perceptible change in the position of the sawtooth in this lamp.

By Mr. Clark:

Q. 114. As I understand it, this sawtooth arrangement is particularly susceptible to sagging, is that correct?

A. That is correct. If the filament shows any tendency to sag this type of construction will magnify that tendency. And that is the reason that I use that here in this demonstration. The type of lamp shown in Exhibits 16 and 18 is the normal construction—the so-called ring type. I have the actual lamps from which these photographs were taken. (Produces lamps.)

Mr. Clark: I offer in evidence the lamp just demonstrated by the witness, the Pacz 218 filament lamp.

(Marked Plaintiff's Exhibit 20 in evidence.)

The Witness: I have here a 60 Watt ring construction lamp of Pacz 218 filament which is the same lamp from which the photograph on the upper left of Plaintiff's Exhibit 18 was taken.

Mr. Clark: I offer that in evidence.

(Marked Plaintiff's Exhibit 21 in evidence.)

The Court: Now, this is a horse shoe lamp?

[fol. 51] The Witness: Yes.

The Court: And that was tested base down in the photograph?

The Witness: That was tested base down, yes, but even after 115 hours it shows no perceptible sag, so one cannot see any change in it in a short time or even in a long time.

Now, the next lamp that I have is a lamp made from Pacz 218 filament after burning 115 hours. It is the same lamp that is photographed at the bottom of the chart, Plaintiff's Exhibit 18. This has already burned 115 hours and showed no sagging.

Mr. Clark: I offer this lamp in evidence as a plaintiff's exhibit.

(Marked Plaintiff's Exhibit 22 in evidence.)

The next one is the thoriated Tungsten filament lamp after flash ageing only. This one will show sagging, if you want to wait long enough. You will note that the filament loops are bowed upwards. It will not take very long for the loops to reverse their position and start downward.

After about a minute two of the loops are already sagging slightly downward, and the third one is nearly straight.

Now the third one is sagging slightly downward.

And if continued for 115 hours, sagging proceeds during the burning until after that period, the filaments appear the same as shown in this next exhibit, which is the thoriated filament lamp after 115 hours burning.

[fol. 52] I mentioned before that is only 11 or 12 per cent. of the life of the lamp.

Mr. Clark: I offer in evidence as Plaintiff's Exhibit 23, the lamp which is shown in the upper photograph of Plaintiff's Exhibit 16, this lamp having now been subjected to current for three minutes.

The Court: And it is entitled "after flash-ageing only."

(Marked Plaintiff's Exhibit 23 in evidence.)

The Court: And the next one, at the bottom of that exhibit, entitled, "Lamp after burning 115 hours."

Mr. Clark: Yes, and that is offered in evidence at this time.

(Marked Plaintiff's Exhibit 24 in evidence.)

The Court: That is what the witness just demonstrated to the Court.

Mr. Clark: Yes, and on both of these demonstrations the base of the lamp was down.

I think we might make the situation a little clearer if I stated that all of the thoriated Tungsten filaments which I have illustrated in the exhibits and shown in my demonstrations are of the same material, they are all regular thoriated Tungsten filaments. And all of the 218 Pacz filaments which I have illustrated in these exhibits and which I have shown in my demonstrations are the same 218 Pacz filament, the regular commercial product of the General Electric Company.

[fol. 53] I have had two different forms of lamps shown in my exhibits and in my demonstrations, the one form the so-called saw-tooth is the form which I used for sag test purposes because it shows up more promptly the sagging characteristics of the filament, tested. The second form that I have demonstrated here and shown in my exhibits, the horse-shoe form, for example, that of Exhibits

16 and 18, is the regular commercial form of lamp produced by the General Electric Company, but I do not use that in my sag test because it takes a longer time with that construction to ascertain the sagging characteristics of any particular filament.

The Court: To sum it up, you brought the saw-tooth ones here to demonstrate to the Court, so that the Court would not have to wait a long time to see it?

The Witness: That is right.

I will summarize what I understand to have been Pacz's accomplishment in the production of this filament which consists mainly of large crystals and which I have demonstrated and talked about. Before Pacz the art was taught to avoid large crystals so that the efforts were concentrated on various ways of keeping the crystals small during the normal life of the filament. And the sagging was endured in order to defeat the bad effects of offsetting which would have impaired the lives of the lamps had the filaments been coarse-grained. So that at the time of Pacz a coarse-grained filament was synonymous with an offsetting filament and it was a thing to be avoided.

[fol. 54] What Pacz did was to gain the advantages of the coarse crystal, which reside in the resistance of the coarse crystal structure to sag, and at the same time to avoid the curse of the large crystal which was offsetting. He avoided it in a manner which is very obvious to one studying his product. He avoided it by never producing a crystal boundary joining large crystals which was either disposed in the right position to offset or which was smooth and which would easily permit movement of one crystal adjacent to another. So that he did in the formation of these large crystals what the art taught not to do, namely, he went out after the production of large crystals and produced them, not late in the burning life of the lamp but very early in the life of the lamp, and obtained what was regarded at the time as practically impossible, obtained a coarse-grained filament which did not offset.

I do not know why the process which he describes in his patent produces a structure such as I have described with the large grains of such size and contour that the filament will neither sag nor offset. We have put a lot of effort into studies relating to the underlying theories and have

discussed the matter with scientists in various parts of the world and no one so far has offered a theory which seems to be satisfying.

The Court: Is Pacz alive today?
The Witness: Yes.
The Court: Does he know why?
The Witness: No.
Mr. Clark: It is what you would call a discovery.

[fol. 55] Such filaments have been used widely and generally commercially. In the last twelve years alone, something on the order of five billions of lamps embodying the Pacz filament have been made and sold in the United States alone. The filaments also used in all other parts of the world. More than 90 per cent of the lamps now manufactured in this country are made of this Pacz non-sagging filament. The General Electric Company itself uses this Pacz non-sagging filament to the extent of more than 90 per cent; and its licensees also.

Mr. Clark: I think that is all.

I now offer in evidence as plaintiff's exhibit the lamp illustrated in the lower left-hand lamp photograph on Plaintiff's Exhibit 19.

(Marked Plaintiff's Exhibit 25 in evidence.)

Mr. Clark: I also offer in evidence as a plaintiff's exhibit the lamp illustrated in the lower right-hand lamp photograph of Plaintiff's Exhibit 19.

(Marked Plaintiff's Exhibit 26 in evidence.)

Brooklyn, N. Y., June 28, 1936.

Met pursuant to recess at 10:30 a. m.; present as before.

ZAY JEFFRIES, resumed the stand.

Cross examination.

By Mr. Darby:

I have testified as an expert for the General Electric Company in the California suit involving the patent in suit. I

[fol. 56] have likewise testified as an expert for the General Electric Company in the case in Delaware involving the Coolidge patent, as regards certain features of the patent. I likewise testified as an expert for the General Electric Company in the previous suit in New Jersey involving the Coolidge patent. I believe it was the case of the Independent Lamp & Wire Company.

X Q. 133. Am I correct in understanding from your direct testimony that the problem of sagging filaments is one which had existed in the art for very many years?

A. Yes, the problem had existed for some years. The problem was not acute with the straight filament lamp which was a vacuum type lamp, but it became quite acute when the coiled filament lamps were introduced.

X Q. 134. Then it was not considered as a serious problem prior to the coiled filament lamps, is that right?

A. It was not considered as serious as offsetting. And by offsetting, I mean the shifting of the crystals with respect to each other in the filament, which caused a rupture in the filament.

X Q. 136. Now, in the patent in suit, beginning at line 20, it is stated that:

"By means of my invention the sagging is substantially eliminated and 'offsetting' of the filament is substantially prevented, during a normal or commercially useful life of the lamp."

I ask you first if it is your understanding that the patented wire eliminated sagging?

[fol. 57] A. Practically so; that is, there is no such thing as absolute non-sagging.

X Q. 137. Now, what is the measure of whether it is a sagging filament or is not a sagging filament?

A. The measure is one of utility. The filament of the prior art was a thoriated filament having fine grains which sagged very badly, especially in coiled filaments.

The filament of Pacz was one which sagged or had a set within the first few minutes of burning while its crystal structure was being established, and after that the steady flow as the result of the force of gravity, produced substantially no further amount of deformation in the metal.

Now, particularly that is measured by the opening of the coils or the increase in spacing between the separate turns of the coils.

X Q. 139. Again you use the word "substantial," in your answer, that there would be no substantial additional sag after the flashing and ageing. What is the measure there?

A. Again I say that is utility, that is a utility matter.

X Q. 140. Can you give me any better gauge than that?

A. I think I can turn to the patent itself and give you an answer which the patentee considered to be substantial absence of sagging. Beginning page 2, line 125, the specification reads:

"The tests on 50 and 100-watt lamps embodying the construction shown in figures 1 and 2 of the drawing show that substantially all of the sagging occurs during the ageing of the lamp. This is when the lamp filament is given the heat [fol. 58] treatment hereinbefore referred to. The sagging was greater in the case of the construction shown in figure 1 than that shown in figure 2 on account of the fact that in the latter there are more supports.

"In the construction shown in figure 1, in the case of 50-watt, 115-volt lamps, in which the filament was 1.62 mills in diameter, and which was made by coiling on a mandril of 5 mills diameter, the turns per inch originally ran from 421 to 430, and after ageing, the average decrease in the number of turns per inch was from 18 to 24. This was under five per cent.

"In the case of the construction shown in figure 2 the decrease was from one to six turns or under two per cent.

"In the case of the 100-watt, 115-volt lamp, in which the filament diameter was 2.63 mills and the filament was shaped by coiling upon an eight mill mandrel, the number of turns per inch originally ran from 257 to 269.

After ageing in the case of the construction shown in figure 1, the decrease in the number of turns was from zero to 10, or less than five per cent, and in the case of construction shown in figure 2, it was from zero to six turns per inch, or less than three per cent. In one case, after a total life of a 100-watt lamp, the number of turns decrease in the case of the construction shown in figure 1 was 12, while in the construction shown in figure 2, it was four."

[fol. 59] X Q. 142. Then am I correct in understanding that it is your testimony and your opinion that a sagless filament

as defined in the Pacz patent is one which does not decrease in number of turns of the coil by more than 12, which is the maximum decrease referred to in the passage that you just read, during the normal life of the lamp?

A. No, I should not wish to try to put any such definite limitation on the Pacz product. He produced a product which had non-sag characteristics of a different order of magnitude from the prior art filament, and at the same time he had a filament which would not offset. So that the combination, the two properties, the non-sagging properties and non-offsetting properties occurring in the same filament, gave him a new product, and I should not wish to try to say just how much his invention could be impaired, as it is described in its preferred form in this patent.

X Q. 143. Now you have given me your opinion as an expert. Now will you give me your statement as a fact: Does the patent say how it can be determined, whether or not any particular filament is or is not a sagless filament as defined and disclosed in the patent?

A. Yes, I think it does.

X Q. 144. Where? Will you point it out?

A. In the portion which I have just read it describes the characteristics of the patented filament, that is, that it assumes its non-sag nature very quickly after the burning starts. That is indicated in the first sentence of the portion which I quoted from the patent. That can only be attained by the development of a coarse crystal structure in the [fol. 60] filament after a short burning time so that the patent teaches that the product of the invention must be one which develops a coarse crystal quickly when it is burned in the lamp.

X Q. 145. You, of course, appreciate, do you not, Doctor, that the claims in suit in this case are limited to the product?

A. Yes, I appreciate that.

X Q. 146. You likewise appreciate that none of those claims recites anything in connection with any process employed for producing the product defined by that? You appreciate that, do you?

A. Yes.

X Q. 147. Now, my problem is this——

A. I would modify that in part, that they imply a mechanical working of the Tungsten as a part of the process in the production of the filament.

X Q. 148. In other words, the mechanical working, such as employed by the earlier Coolidge patent?

A. Yes.

X Q. 149. Now, my problem is this, and I solicit your aid: For one to determine whether or not in building a lamp the filament of the lamp would come within or without the monopoly defined by those product claims, how great a degree of sag is permissible. That is the first. And the second, does the patent state how great a degree of sag is permissible? First, in the flashing and ageing, or at least after flashing and ageing, second, during the normal life of the lamp.

A. I believe that your first problem is not my problem. That is, as I stated before——

The Court: You think maybe that it is my problem?

[fol. 61] The Witness: Yes.

The Court: I supposed that was what you meant.

Mr. Darby: Undoubtedly that is true. But I am confining my questions to the witness to eliciting from him as an expert what is and is not a sagless filament, as defined in the claims, which, of course, he is qualified to answer.

The Witness: If it would help, it may be that it would help, I may say that the perfect product of the Pacz patent is practically non-sagging after the first few minutes of burning of the filament. That is, coils mounted in a lamp stay approximately in the same position for hundreds of hours when the lamp is burned at a normal voltage. Naturally that assumes that the filament is given some help by the engineers, that is, that the normal stresses due to gravity are not greater than the so-called elastic limit of the metal between supports. Under those conditions, as the patent says, sometimes throughout life no change can be observed in the spacing of the coils after the first few minutes of burning.

In other cases only a very moderate change can be observed after long burning.

Now the distinction is that the product of the Pacz patent does not flow or creep continuously throughout its life at a rate which would impair the electrical efficiency of the lamp or the mechanical efficiency such as change of position of the filament during burning. Now, as to just how [fol. 62] far one can depart from the perfect patent product toward some other product of the prior art and still remain within the scope of the teachings, I am not prepared to say.

X Q. 150. And the patent doesn't say it either, does it?

A. Not in any specified numerical figures, no.

X Q. 151. Now, crystallizing on your first point, Doctor: As I understood your statement, it was that a non-sagging filament, as you understand the term as used in this patent, is one wherein there is no substantial sagging after the ageing treatment. Now, my next question is: referring to Plaintiff's Exhibit 18, and if we accept the straight wire shown in the photograph entitled "Enlarged view of coiled filament after flash-ageing only," assume that that wire was in that condition before flashing, but after flashing it assumed the position shown in Plaintiff's Exhibit 16, the photograph in caption "Enlarged view of coiled filament after 115 hours of burning," would you say that this latter filament was a sagless filament?

A. That has too much sag for a flash-ageing operation in a good Pacz filament.

X Q. 152. I agree with you, Doctor. Now I want to know where is the dividing line?

The Court: Well, he conceded that that is the dividing line, or beyond it.

X Q. 153. I want to know where the dividing line is—where is the dividing line, Doctor?

Mr. Clark: I think the witness has given all the information he has been requested on that point. I think that is [fol. 63] a matter for the Court to determine in respect to this particular alleged infringement.

The Court: I believe that the witness has interpreted it to the best of his ability. I do not think, however, that it is an unfair question. He has one idea in view, but if he can answer it and throw any light on it for me, it will be helpful.

Mr. Darby: If the witness will say what I understand to be a fact, that there is no dividing line disclosed in the patent, as a guide, I am through with the subject.

The Court: I think that he says there is something in the patent itself that sagging means a certain thing, and beyond that he is not prepared to go.

X Q. 154. Will you agree with me that the patent does not give any dividing line?

A. I said it did not give a dividing line in figures. However, I think I can answer in a way the question that you put

to me. It is this: If a filament, during the normal flash-ageing would change from a horizontal position to the position shown in the picture of the filament enlarged ten times on the lower left of Plaintiff's Exhibit 16, and would sag no more throughout its whole life, that would be a non-sag filament, but engineers would be foolish to take a filament with those properties and give it a mounting such as is used in the lamps shown in the photographs, Plaintiff's Exhibit 16.

X Q. 156. Now let me put the next question which I think will complete the subject. If the lamp, after flashing, had [fol. 64] its filament in a substantially horizontal position, as shown by the second photograph from the bottom, Plaintiff's Exhibit 18, and it assumed the position as shown in the second photograph from the bottom to the left, Plaintiff's Exhibit 16, during its normal operating life, would you say that the filament was a non-sag filament?

A. In the sense that the term is used in the patent in suit, I would not know without examining the particular filament and the construction of it.

X Q. 157. You could not tell then by comparing those two filaments whether a substantial sag had occurred from the one condition to the other?

A. Not without knowing the size of the wire and the size of the coil and the distance between the supports, and so forth.

X Q. 158. But you used these two exhibits, did you not, to illustrate to the Court the comparison between a non-sag filament and a sagging filament?

A. That is correct; one of them showing practically no sag, and the other one a considerable amount of sag, changing from not the straight but upward bowed position to a downward bowed position in approximately 11 or 12 per cent. of the life of the lamp. Furthermore, the sagging one continuing to sag, with additional burning, and the other one remaining substantially in its original position as the burning was continued.

X Q. 159. I presume that if I added to my question that the lamp had only been burned 115 hours and it assumed this position from a substantially horizontal position, you still could not tell me whether or not that was a sagging filament?

A. Yes, if it sagged gradually throughout the 115 hours, it was a sagging filament.

[fol. 65] X Q. 160. Going back to the specification of the patent where we left it, in the passage that I read to you, reference was made to offsetting. The problem of offsetting had been solved by the Coolidge patent, had it not?

A. In one way, yes.

X Q. 161. Taking up the process described by the patent, and having in mind particularly the process employed by the General Electric Company in making the commercial lamps that it sells as sagless filament lamps, the specification says: "In the preferred form of my invention I bring into intimate association," and I am reading from line 26, "I bring into intimate association with tungsten a material which will have the desired influence upon the grain growth of the metal. I precipitate, simultaneously, compounds from which the metal is to be directly reduced with the material or compound which is to accomplish the desired result."

Now, in the manufacture of the General Electric commercial lamps is that practice employed?

A. Yes.

X Q. 162. Simultaneous precipitation of the tungsten and the metal?

A. Yes, it is a precipitation of the tungsten oxide in the presence of these other materials.

X Q. 163. You are sure that that is the commercial practice as they are employing it, as they employ it in making the so-called sagless filament lamps?

A. Yes, it embodies that as one step.

X Q. 164. Does the General Electric Company do anything in addition to that at that stage of the process in producing its commercial lamps?

A. They do something to insure the intimate association [fol. 66] of these added materials with the tungsten oxide.

X Q. 165. And what is that?

A. After the precipitation of the tungsten oxide in the presence of these additional materials takes place, the precipitate is washed to a greater extent than that which is described in the specification in the patent in suit.

X Q. 166. What part of the specification are you referring to?

A. Page 2, line 17. The statement occurs:

"The precipitate is then washed with hot H_2O until the filtrate becomes milky." That is an incomplete washing,

which the specification of the patent in suit describes. In the present process the washing is more complete and then the resulting oxide is analyzed for alkali metals and for silica, and it is usually found that the percentage of these materials remaining in the oxide is less than that which is desired. After analysis, potassium salts, sodium salts and compounds of silica are added to the tungsten oxide mixture to bring the total quantities of these substances up to a certain fixed amount. After that the process is carried on exactly as described in the Pacz patent in suit.

X Q. 167. Now, the Pacz patent in suit describes the process in the following fashion, it forms a solution which is called Solution A; and it describes the formation of a solution which is called Solution B. Then a treatment of those two solutions together, or parts of them together, to form what is known or termed a metal A. Then the formation of what is termed a metal B. And then an alterna- [fol. 67] tive arrangement, namely, the formation of what is termed the metal Z, is that correct?

A. Yes.

X Q. 168. I would like to review the steps of each of those processes in connection with the General Electric practice. First, however, let me ask you in connection with lines 66 to 71, where it says:

"As hereinbefore stated, the material which is intimately incorporated with the metal," and which is previously described as silica, I believe, "should be such that it will be volatilized out after the metal has reached the temperature of rapid grain growth."

Now, does that mean that this added metal is burned or otherwise gotten out of the ultimate filament so that the ultimate filament is substantially metallic, with no non-metallic ingredients left?

A. No, it doesn't mean that, at least quantitatively. First I might say that the materials added are not properly described under the one name silica. The materials include silica and alkali metals both at the same time.

Now, it is true that most of these added materials are volatilized out. The extent of the volatilization, however, is not given quantitatively in the specification, but there are some statements, I think, in the specification which indicate that a small amount of these materials may remain in the final metal after the volatilization or sintering treatment.

X Q. 169. Let me call your attention to the statement occurring on page 2 of the patent, beginning at line 80:

"In the case of the '218' ingots analyses have shown that [fol. 68] the percentage of non-metallic material is below two-tenths of one per cent and in many cases below one-tenth and even one-twentieth of one per cent."

Does that modify your previous answer in any respect?

A. That gives the information which I was about to get from the patent, yes.

X Q. 170. Taking up the exact steps, first, the production of Solution A, beginning at line 89, it is stated that:

"A fusion of materials is first made which is quite similar to that disclosed in my Patent Number 1,299,017 issued April 1, 1919. 1400 grams of commercial tungstic acid."

Does the General Electric Company in producing its commercial lamps under this patent use commercial tungstic acid, or does it use pure tungstic acid?

A. It usually makes its own tungstic acid from the tungsten concentrate. They make it as pure as they can.

X Q. 172. There is a distinction between commercially pure and chemically pure, isn't there, in metallurgy?

A. Sometimes, but I think there is no distinction in this case. The statement, by the way, is not commercially pure, it says "commercial tungstic acid."

X Q. 173. That is not as pure as chemically pure, is it?

A. Not as pure as chemically pure, but no tungstic acid that is used, so far as I know, is chemically pure.

X Q. 174. And commercially pure tungstic acid is not as pure as tungstic acid used by the General Electric Com- [fol. 69] pany in the manufacture of its filament?

A. Yes, it is called a commercial acid.

X Q. 175. Does the General Electric Company use that same proportion, 1400 grams, with reference to the remainder of the ingredients?

A. At the present time, no.

X Q. 176. They use more or less than 1400 grams, in proportion with the other ingredients?

A. No, that has been changed since the operation is on a large scale.

X Q. 177. But I am talking of proportion.

A. Again those proportions are arrived at by using mixture of alkaline silicates in two ways: one, in the original mixture present during precipitation, and the other, additions after the washing, to bring the alkaline silicate content up to a certain amount, so that the process as described here in small batches is not practiced quantitatively in this way at the present time. It was practiced for several years just like the description in the patent, but at the present time the process is practiced on a much larger scale. The present commercial operations of the General Electric Company do not follow the proportions recited in this paragraph of the patent. The particular proportions in the large batches may not be the same as those described in the patent.

X Q. 179. When did you discontinue that practice? You said that you followed the practice just as in the patent for a few years. When was that practice discontinued and the present practice adopted?

A. About 1921 or 1922.

X Q. 180. You still, however, in the manufacture of your commercial lamps, make this Solution A, don't you?

A. No.

[fol. 70] X Q. 181. What do you do instead of making Solution A?

A. We make the alkaline silicate solution direct and add it in one solution, instead of adding it in two solutions.

X Q. 182. In other words, you make one solution instead of the two separate Solutions A and B, as described by the patent, is that correct?

A. That is correct.

X Q. 183. When was that practice adopted, about the same time, 1921?

A. Yes, 1921 or 1922.

X Q. 184. Now, in your one-step commercial process, then, you obtain the precipitate which is dried and ignited in a quartz dish, is that right?

A. It is dried and ignited, but not in a quartz dish. It is ignited in some other crucible or receptacle.

X Q. 186. And is it reduced in hydrogen as the next step in your commercial process?

A. After analyzing for additions and then adding the additional alkaline metals and silicate, the oxide is then reduced with hydrogen.

X Q. 187. And is it the metal that you thus produce that is worked in accordance with the Coolidge patent to produce your sagless filament?

A. No, we still go through the double reduction step described in the patent.

X Q. 188. Beginning where?

A. This first metal produced is described at page 2, line 22, as: "The metal thus produced may be termed metal A.

"The metal A may be pressed up and sintered to produce tungsten slugs which may be drawn into filaments having the non-sag and other characteristics hereinbefore described. I prefer, however, in order to obtain greater uniformity of product to continue the operation as follows:

[fol. 71] "About 1200 grams of metal A are mixed with about 1200 grams of the oxide from which metal A was reduced, the mixture being very intimate and being performed preferably in a tumbling mill. The mixture is then reduced as before although 150 gram charges may be here used. The metal thus produced may be termed metal B. It is then sieved, pressed into ingots and sintered in the usual way as set forth in the Coolidge Patent No. 1,082,933."

We still use that so-called double reduction method which the patent describes as the preferred method. We produce a metal "A." And we use approximately equal parts of metal "A" with the oxide from which the metal "A" was reduced to form metal "B," and then reduced. It is the metal "B" that is then worked to produce the sagless filament under the patent in our commercial practice.

The next paragraph of the patent refers to a modification. The General Electric Company has never produced commercial lamps under the modified process there described.

X Q. 195. Now, we come to the statement of the patent which was subsequently disclaimed. It says "The metal obtained from the first method above described I have called 218, a purely arbitrary name. I have produced a metal differing in appearance and physical characteristics from 218 metal, by adding a solution of boric acid to chemically pure tungsten oxide by evaporating, drying, igniting and reducing." That is what was disclaimed. What was

not disclaimed continues. "The metal thus produced when made into wire is superior to 218 in non-sagging or non-offsetting characteristics, but a combination of this method [fol. 72] with that for producing 218, in which tungsten acid from the latter is mixed with that from the former produces a metal which I term Z and which is efficacious in the production of non-sagging and non-offsetting filaments."

Mr. Clark: You were not quite accurate as to how far the disclaimer went. It went from 52 to 59.

Mr. Darby: I am sorry, 52 to 59. You are right, Mr. Clark, thank you.

X Q. 196. Now, I am particularly interested in the next statement: "To produce this metal, (referring to boric acid, metal Z), in 500 cubic centimeters of water" one method which I have practiced is to mix one kilogram of the tungstic oxide from which metal A is reduced in the 218 process with a solution of 12.5 grams fused B_2O_3. Is that your understanding, that the metal thus produced contains an alkaline silicate?

A. Yes, because metal A contains the alkaline silicate.

It has been the practice for a great many years prior to the date of the application for this patent in suit to treat the commercial lamps, to give them a flash ageing treatment. That is standard practice; the schedules vary, of course.

X Q. 200. The next passage of the specification that I call your attention to, is that appearing on page 2, line 119, "Heretofore it was impractical to make a lamp like this," referring to figure 3 of the patent, "having a single coiled loop filament for use at ordinary voltages. The non-sag characteristics of my wire render this construction possible for all of the ordinary voltages and wattages." Has [fol. 73] the General Electric Company turned out any commercial lamps with that type of filament of non-sag, to your knowledge, of the arrangement shown in figure 3?

A. I think the exact construction there is not used commercially at the present time, although I think some of the candelabra lamps have mountings somewhat similar to that shown in figure 3.

X Q. 201. When you say, are not used at the present time, were they ever produced commercially?

A. I cannot say exactly what the constructions were of the commercial lamps. I have no definite recollection now that they were ever produced commercially as shown in figure 3, as a sagless filament.

Again referring back to page 1 of the patent, on line 91, reference is made to a previous patent, Pacz patent No. 1,299,017. I am familiar with that patent.

Mr. Darby: I ask to have a copy of Pacz patent 1,299,017, granted April 1st, 1919, on an application filed May 25th, 1914, and referred to in line 91 of the patent in suit, marked for identification.

(Patent marked Defendants' Exhibit A for Identification.)

X Q. 204. Beginning at line 17 of this patent, the prior Pacz patent, it states: "My invention is applicable to metals which are produced by mechanically working an agglomeration of finely divided metals. An example of such a metal is tungsten, which is produced in a wrought and drawn state by the process described in Coolidge Patent No. 1,082,933, issued December 30, 1913.

[fol. 74] "One of the main difficulties which is met with in the case of metals in general is that, when subjected to the severe stresses incident to their use in the arts, they lose to a large extent the characteristics which they originally possessed. This is particularly true of metals which are subjected to heating at a high temperature, as by heating to incandescence. Under such conditions, as a rule, metal bodies lose their pliability and, moreover, tend to lose their original form or shapes."

Do you understand that to mean that they tend to sag?

A. Possibly, that is what would be included, I think.

X Q. 205. "Another difficulty is that high heating or other stress causes the metal to crack." Do you understand that to mean offsetting?

A. No, I haven't heard the offsetting expression used to indicate cracking.

X Q. 206. All right, we will continue. "In the case of wrought or drawn tungsten which is made into filaments for incandescent lamps, this failure to retain its original properties is quite striking. Although the said metal is pliable and will take a set as originally made, after its use in the incandescent lamp it becomes quite brittle and sags, losing

its original shape. Moreover, unless means are taken to lessen the tendency to crack, cracking will occur and produce the condition known as offsetting."

Now, the patentee Pacz, in this prior patent, as in the passage I have just read to you sets forth two features of the problem, which two features alone comprise the problem of the Pacz patent in suit, namely, that of offsetting and sagging, does he not?

A. Yes, he stated that problem.

[fol. 75] The Court: Does this one work?

Mr. Darby: On its face it does, it is presumptively valid.

The Court: I mean, did the lamp work?

Mr. Clark: This was co-pending with the patent in suit, your Honor. It is not prior art.

Mr. Darby: I disagree with that.

The Court (To witness): Did this one work, Doctor?

The Witness: No.

The Court: He stated the problem, but he was not able to overcome it?

The Witness: It was an improvement over the thoriated filament.

X Q. 207. Did I understand you to say, Doctor, in your opinion, this patent was inoperative?

A. No.

The Court: He said it improved it, but it did not overcome the problem.

The Witness: It was not as good a one as the patent in suit, and although the metal was available prior to the availability of the Pacz 218, and while thoriated filaments were in use, it was not substituted even for the thoriated filaments.

X Q. 208. As long as the Court brought up the question, I might pursue the thought. This prior Pacz patent was operative, wasn't it?

A. Yes, it produced filaments which would burn in a lamp.

X Q. 209. Did it produce filaments which would burn and not sag and not offset?

A. It would not produce filaments which would not sag. [fol. 76] As to the offsetting I cannot say from personal experience.

X Q. 210. Then, if—and my question is predicated upon "if"; if this patent is directed to producing a filament which

will not sag or offset, is it your testimony that the patent is inoperative for that purpose?

A. Yes, it is inoperative for that purpose because he does not state that the filament will not sag. He states the problem, but he does not state that the filament does not sag.

Mr. Darby: You will concede, Mr. Clark, will you, that no disclaimer has been filed in connection with this prior Pacz patent?

Mr. Clark: I don't know anything about it.

Mr. Darby: I will state it, are you willing to accept that subject to correction?

Mr. Clark: Certainly.

X Q. 211. And so to continue, Doctor: The patent states, beginning at line 48: "Offsetting is a lateral shifting of one section of filament with respect to the adjacent section. There are methods in use for preventing offsetting. These are described in the aforesaid Coolidge patent, and also in Frech Patent No. 1,089,757, March 10, 1914. In a general way these methods are similar in that they consist in incorporating with the tungsten or rather the oxid from which the tungsten is derived, certain foreign materials such as those obtained by firing the tungsten oxid in a Battersea or Hessian crucible, or by firing it with a compound of thorium. Although these methods have proven efficacious, they have the [fol. 77] disadvantage that the introduction of foreign material of this kind into the filament is apt to have deleterious effects. I will pause there for a minute. Quite contrary to the statement of Mr. Pacz, the Coolidge patent specifies that the introduction of foreign materials by the use of the Battersea crucible has a beneficial effect; is that correct?

A. Yes, it has a beneficial effect against offsetting.

X Q. 212. Then again, to line 78, the patent states:

"The object of my invention is to produce a metal which will possess in a much higher degree than any metal of the same name heretofore produced, the characteristic of retaining its original properties when subjected to severe physical stresses. I attain this object without adulterating the metal."

Then, at line 95:

"I have produced metals having the desirable properties hereinbefore described which ran from 99.7% to 99.95%

pure tungsten. These metals were pliable and showed no offsetting after continued use as filaments in incandescent lamps. Moreover, coiled filaments made from these metals retained their shape to a very high degree after continued use."

Do you understand from that Mr. Pacz was stating that the filaments made by him under this patent neither offset nor sagged in the sense that that term has been used in [fol. 78] in this trial?

A. No, I think not. He says definitely that they did not offset. Then, he says that they retain their shapes to a very high degree with continued use, but he does not——

X Q 213. That means they did not sag substantially?

A. He doesn't say so. He was comparing this with a thoriated filament which sagged badly throughout life.

X Q. 214. What justification have you for the statement that he was comparing it with the thoriated filament as distinguished from the Battersea filament?

A. Because the thoriated filament was the filament in use at the time Pacz filed his application.

X Q. 215. But the patent itself refers also to the Battersea filament?

A. Indirectly, by reference to the Coolidge patent.

X Q. 216. It refers to it expressly in the passage that I read to you at line 60, does it not?

A. It refers——

X Q. 217. Can't you answer that question yes or no, Doctor, and then explain it?

A. It merely refers to Battersea or Hessian crucible method as having been one that had solved the offsetting problem.

X Q. 218. Can't you answer that question no or yes, Doctor? And then explain it in any way you want.

A. It merely refers to the Battersea or Hessian crucible method as having been one which had solved the offsetting problem in the patent.

X Q. 219. The patent specification at line 60 refers expressly to the Battersea crucible process, doesn't it?

A. Yes, it mentions it, but it doesn't say that the wire was in use at that time.

[fol. 79] X Q. 220. Then, as I understand it, it is your testimony that the statement beginning at line 100, "More-

over, coiled filaments made from these metals retained their shape to a very high degree after continued use," does not in your opinion mean that it does not sag substantially?

A. That is correct. I might modify that statement by reference to another part of the Pacz patent specification, that is, Pacz patent 1,299,017, beginning line 121, page 3:

"My wire also showed no tendency to offset. I have found that a test which may be applied to wire which will show whether it will offset in the lamp is to give it what is known as the cross-section test. For this test a rod of a metal of 80 mils in diameter is heated for 8 minutes in hydrogen at a temperature close to the melting point of tungsten. The rod is then fractured and the cross-section examined. If the cross-section is shiny or shows coarse grains, the filament will offset. On the other hand, if the structure is finely granular, the filament will not offset. Rods produced from the metal, as above described, when subjected to this test had cross-sections which were finely granular."

This quotation shows that Pacz was curing the offsetting by making a metal which was finely granular. In other words, by the same method which had cured the offsetting in the previous filaments made by Coolidge. Such a filament which is finely granular sags. Filaments of the kind described by Pacz in this patent are not as finely granular as the thoriated filaments and do not sag as much as the [fol. 80] thoriated filaments. So in the sense that they retain their shapes to a very high degree after burning, the comparison, I am sure, is with the badly sagging thoriated filaments of the prior art.

The thoriated filament of the prior art would sag very badly.

X Q. 222. And along comes Pacz, by the patent for which he applied in 1914, and he produced a filament which would not offset and which would not sag as much, is that right?

A. That is what is stated here in the patent.

X Q. 223. That is what it means to you as you testified?

A. That is correct.

X Q. 224. And then comes Pacz with the patent in suit and produced a filament which likewise will not offset and which will not sag quite as much as the previous Pacz patent, is that the substance of your testimony?

A. No, the filament of the Pacz patent in suit does not offset and its non-sag character is of a different order of magnitude even from that of this earlier Pacz patent.

X Q. 225. That is just what I said, isn't it?

A. No, you implied that there was probably just a little difference in the sag tendency.

The Court: The only difference is, you say a little and he says it is a great one.

Mr. Darby: And I want to find out from the witness from the disclosure of the prior Pacz patent No. 1,299,017, and the Pacz patent in suit, from their disclosures the justification for the statement that my "little" is wrong and his order of magnitude is right.

[fol. 81] The Witness: The distinction, I think, can be stated best in this way——

X Q. 226. I want it directly from my question, Doctor. I don't want to get into a scientific discussion with you because I know I will be bested before you start. Consequently, I am confining you to the questions that I am asking at this stage, and I ask that they be answered. You point out from the patents themselves where a measure may be made between the two of them.

A. Yes. In the earlier Pacz patent he teaches that you must get a fine grain in order to avoid offsetting. He teaches also that if a large grain is produced, the wire will be offsetting. Therefore, the finely granular structure of the filament must be retained for a long time when the filament burns. Therefore, the sagging will continue a long time when the filament of the earlier Pacz patent is burned in the lamp. When it is non-offsetting it is a sagging filament. If it reaches the stage of a non-sagging filament, it will be an offsetting filament. Therefore, the filament sags early in life and it may offset if it reaches a truly non-sag character, may——

X Q. 227. Is this all in the patent?

A. Yes, it is in the patent by description and by the knowledge of those skilled in the tungsten filament art.

For example, again, on page 4 of the earlier Pacz patent, line 3, occurs this statement:

"If the cross-section is shiny or shows coarse grains, the filament will offset."

This earlier Pacz patent, therefore, teaches that you must avoid the coarse crystals in order to avoid offsetting. [fol. 82] If coarse crystals are avoided, there is no escape from the sagging of the filament.

In the Pacz patent in suit it is stated, page 2, line 126: "The tests on 50 and 100 watt lamps embodying the construction shown in Figs. 1 and 2 of the drawing show that substantially all of the sagging occurs during the aging of the lamp." In other words, a non-sag structure is obtained in a relatively few minutes in the Pacz filament of the patent in suit.

Furthermore, on page 1 of the patent in suit, beginning line 60, occurs this sentence:

"The probable reason why filaments made according to my invention do not sag, is that the structure is comparatively coarse grained."

That is, the patent in suit leads one to the production of coarse grains immediately in the filament.

Then he goes on to say, line 63:

"The coarse grained filament produced by means of my invention does not 'offset' so as to cut short the life of the lamp appreciably."

So that, by comparing the teachings of the two patents, the Pacz patent in suit tells you that by his method you can obtain coarse grains without danger of offsetting. So that the advantage of the non-sag nature of the filament is gained from the very start of the life of the lamp without fear of offsetting.

[fol. 83] By the Court:

Q. 229. That is his teaching, isn't it, in those patents?

A. Yes.

Q. 230. Supposing we get at it this way: Here is this Exhibit 16, which is the Coolidge patent, practically, isn't it?

A. Yes.

Q. 231. Taking the second one from the bottom on the lower left hand, that shows the extent of sagging at the end of 115 hours, right?

A. Yes.

Q. 232. We will use 115 hours as our basis for a practical answer instead of a theoretical one, such as you just gave

me. I would rather have a practical answer. You have here Exhibit 18 showing the amount of sagging after 115 hours, as shown on the right, the second one from the end, is that right?

A. Yes.

Q. 233. Now, that is the Pacz patent in suit, isn't it?

A. Yes.

Q. 234. Now, there is another Pacz patent introduced in evidence, 1,299,017, is that right, that you just compared in your previous answer to Mr. Darby, is that right?

A. Yes.

Q. 235. And in that you say, "We improve the sagging over the Coolidge patent as shown in Exhibit 16," is that right?

A. Yes.

Q. 236. Now, using the basis of 115 hours for our practical discussion, I think you tried to say to me that the Pacz patent, the earlier one, improved the sagging somewhat between Exhibits 16 and 18, is that right?

A. Yes.

Q. 237. Now, can you give me that in relative terms of percentage? Take the Coolidge one at 115 hours. You may take any percentage you want for that. You can say it is [fol. 84] 30 per cent., for instance, or 25, of sag, or 10 per cent. I do not care what percentage you use. Tell me the improvement in the earlier Pacz patent and then the improvement in the last patent, if you can. Now, if my question is unfair, say so. Can you answer that question fairly, Doctor?

A. Yes, I can answer it fairly, but it will not be an answer which will give any quantitative measure of the sag.

Q. 238. Supposing we put it this way: Suppose we take this Coolidge patent, Exhibit 16, the lower left hand one, and suppose we use as a basis that that has a 20 per cent. sag. I am using that merely as a basis. It is some part of 100 per cent., isn't it, Doctor? If you draw a straight line, across, that would be 100 per cent perfect?

A. Yes.

Q. 239. Now, this is less than 100 per cent. perfect, isn't it?

A. Yes.

Q. 240. Will you say that that is 80 per cent. perfect, in terms that I can understand? Suppose I was a student and you were teaching me. You would say this filament in Ex-

hibit 16 is 80 per cent. perfect. Now will you adopt that as a basis, which may not be real? Now, the earlier Pacz patent improved that, didn't it?

A. Yes, it improved it.

Q. 241. How much did it improve it, by a half or a quarter or one-third, put it that way? Of course, we are using a basis of 115 hours, that is understood.

A. I must answer that by saying that the improvement was not a certain and definite improvement quantitatively.

Q. 242. All right, give us the high and low of it.

A. No, I am afraid I cannot even do that because I must go back to this proposition that the filaments were of a dif- [fol. 85] ferent nature, that there is no suggestion that the filament of the earlier Pacz patent would be non-sagging and non-offsetting at the same time.

Q. 243. I am not concerned with that. Suppose we put it this way: Did you see any of these lamps that were made on the earlier Pacz patent?

A. I tested filaments that were made by a process approximating that of the earlier Pacz patent.

Q. 244. And were they ever made commercially?

A. No.

Q. 245. Those that you tested, tell me what you found as a result of your tests in regard to the sagging only, never mind the properties—what did the sagging show, if you can tell me?

A. They sagged badly at the beginning of life and continued to sag for a long time.

Q. 246. Up to 115 hours?

A. I would not say exactly the number of hours.

Q. 247. But still it was an improvement over this Coolidge in Exhibit 16?

A. Yes.

Q. 248. It did not sag as badly as that?

A. That is correct.

Q. 249. You are not prepared to give me any per cent., because it varied?

A. That is correct.

Q. 250. But they did definitely improve the Coolidge one somewhat?

A. Yes, but there is another feature——

Q. 251. Suppose you keep that out of it a minute. Now we come to Exhibit 18. You say that the patent in suit—

this is the amount of sagging that you find in the two figures next to the bottom, and the third from the bottom on the right side?

A. Yes.

[fol. 86] Q. 252. Would you say that is pretty perfect, Doctor?

A. Yes.

Q. 253. I would say so from looking at it.

A. Yes.

Q. 254. The earliest Pacz patent did not do as well as that

A. Not nearly as well.

By Mr. Darby:

X Q. 255. Now, you do not mean to imply, do you, Dr. Jeffries, that that is the non-sagging position of the filaments manufactured by the General Electric Company from the Pacz patent in suit in all commercial lamps today?

A. Yes.

X Q. 256. It is?

A. Yes.

The Court: Of course, that is based on 115 hours.

Mr. Darby: I will show him some lamps that will make him change his mind on that, that have not been burned at all.

The Court: The first one at the top is flash aged, and the other 115 hours.

X Q. 257. I have used this one of 115 hours as my basis.

A. I might say that the filaments take different shapes during flash aging, sometimes more droop than at other times, but after the flash aging is completed there is very little change.

X Q. 258. As a matter of fact, in your commercial lamps, rarely, if ever, are they in virtually a straight line after they have been flash aged, are they? It is very rare?

A. Some loops are. You may note the additional loops that can be seen in the background of Exhibit 18 are not straight.

[fol. 87] X Q. 259. Would you call those sag filaments?

A. No, those represent the sets taken during the flash aging.

X Q. 260. You do not consider that they have sagged?

A. No, we call that deformation during aging.

X Q. 261. I notice there is a similar loop to the right of the photograph entitled "Enlarged view of coiled filament after 115 hours burning" in Exhibit 18. Do you call that sag?

A. No, that is a set taken in the first two minutes after the lamp has been lighted up.

The Court: Do you take into consideration the fact that this was after 115 hours burning? These loops here (indicating), is that a loop of the wire that burns, this short one here?

Mr. Darby: No, sir; I mean this one here (indicating) where it is hanging down at the extreme right.

The Court: Yes, I am starting over here where there is a white figure. It goes straight and then it bends a little.

Mr. Darby: Yes.

The Court: That is the way the filament looked after 115 hours, is that right, Doctor?

The Witness: That is correct, but the same type of bending down would have been observed in that filament after the flash aging.

The Court: Whether it was two minutes or 115 hours, you would not say that that sagged?

[fol. 88] The Witness: No. In Exhibit 18 the lamps themselves were photographed as shown on the left. The lamp photographed on the top and bottom left is the same lamp.

The Court: I know that, Doctor, these are the same lamps (indicating)—the photographs on the right are enlarged views, and the photographs on the left are really natural views?

The Witness: Except that the photographs on the right are from companion lamps which were broken to get the sections shown at the top and bottom of the page.

The Court: But the right hand figures are enlarged views?

The Witness: They are enlarged, but they are from companion lamps of the two on the left.

The Court: That is a fair representation of a great percentage of your lamps?

The Witness: That is correct.

The Court: You cannot say that every particular lamp would look like that? What percentage would you say, 98 per cent. or 99 per cent.? You must have obtained some degree of perfection.

The Witness: The filaments take all sorts of shapes during flash aging. No two are quite exactly alike.

The Court: But they do not go up any higher or lower than the view you have shown in that exhibit 18 at the top and the left?

[fol. 89] The Witness: They may.

The Court: The range may be a little bit more or less?

The Witness: That is correct.

The Court: Then after 115 hours, shown at the left, is the range any greater or less than shown there (indicating)?

The Witness: After the flash aging, then the filaments change very little during the rest of life.

The Court: They are set and they stay there?

The Witness: Yes.

The Court: Those figures that we have down at the left and right, after 115 hours, are typical examples of the great majority of the lamps that are made for commercial use, is that right?

The Witness: That is correct.

The Court: I mean in regard to the range of the filament going up and down.

The Witness: Again, as I say, different types of lamps with different numbers of supports and different wattages have influence on the shape which the filament takes after flash aging.

The Court: I mean, the extent of the sag would not be much different in any of your lamps than shown on the two photographs on the left and right, after 115 hours?

The Witness: Yes.

The Court: Do you see the one on the left that has burned 115 hours?

The Witness: Yes.

[fol. 90] The Court: And then you have an enlarged one on the right that has burned 115 hours?

The Witness: Yes.

The Court: I think that what you intended to try to show to me was that that is the way your commercial lamps look after burning 115 hours?

The Witness: That is correct, provided they looked about this way after flash aging.

The Court: Now, is the extent of sag which is in these lower photographs—I can see there is very little—is that about the extent of the sag in a great majority or a large percentage of your commercial lamps?

The Witness: Yes, it is.

Mr. Darby: There is a good clear-cut issue of fact.

The Court: That is what I am trying to do. I do not want to be taken away from the situation. I assume these photographs are in evidence to show the typical—of course, one lamp or two or three out of a thousand, may go off that particular line shown in Exhibit 18. I will say right here and now that I will not hold that that is going to have any influence on my decision. I am not going to take the exceptions, the small exceptions; I will take the rule.

Mr. Darby: Of course not, your Honor. If I walk to the corner store and buy a dozen lamps and eleven out of the twelve are sag filaments, that is something else.

[fol. 91] The Court: That is right, and on the other hand if eleven out of the twelve are not, you must take the onus of that situation.

The Witness: I am afraid that the main issue, however, is being avoided. What I wish to make clear is that there are admittedly thousands of shapes that these filaments take during flash aging.

Naturally, as few supports are used as possible, and in some types of lamps during the flash aging there will be a considerable amount of original set and in some not so much original set. In any case, after the original set has taken place in the first few minutes, there is very little change after that.

The Court: I do not think we are far from each other.

X Q. 262. All right, then, coming back to where we were in connection with the prior Pacz patent—will you agree with this statement, Doctor: That neither the Pacz patent in suit nor the prior Pacz patent gives any measure by which it is possible for one to tell where the first Pacz patent stops and the second Pacz patent begins with respect to the degree of sag of the filament; will you agree with that statement?

A. No, I do not believe I could agree with that.

X Q. 263. All right, then we go right back to my original question that I asked and that elicited a rather lengthy answer, and I will press the question and try to press the rules of evidence on its answer. Will you please give me the page number and line, and nothing else, in the first Pacz patent, [fol. 92] which states the maximum or minimum degree of sag contemplated by that patent as obtained in accordance with the invention?

A. There are no such statements, so far as I know.

X Q. 264. Now will you please turn to the Pacz patent in suit and do the same thing?

A. The only figures given are contained in the portion of the specification beginning at page 2, line 126 and ending at page 3, line 30.

X Q. 265. Doctor, to continue from that point, I notice that in all of your exhibits, the photograph exhibits of comparison, you compare the Pacz filament with the thoriated filament which I understand is manufactured in accordance with the teaching of the Coolidge patent, is that right?

A. Yes.

X Q. 266. The Coolidge patent, in fact, describes two types of filament, doesn't it, one which is the thoriated filament and the other which is the Battersea filament?

A. Yes.

X Q. 267. As a matter of fact, the Coolidge patent describes the Battersea filament as the preferred filament, doesn't it?

A. It gives more attention to the Battersea method, yes.

X Q. 268. You say it gives more attention. Isn't it a fact that the only paragraph out of a ten-page specification devoted to the thoriated filament, is contained on page 7, beginning at line 1?

A. Yes, that is correct, I believe.

X Q. 269. And as a matter of fact, the Battersea or Hessian process is specifically claimed as the invention, as part of the invention of a patent, whereas the thoriated filament, is not, isn't that correct, or that the filament obtained in the thorium process is not? And I call your attention to claim [fol. 93] 13, for example.

A. I have not seen the claims for so long, that I cannot say that—I note that claim 13 mentions the Hessian or Battersea specifically, but also claim 14 states that the tungsten powder contains additional material which would prevent coarse crystals and so forth, without mentioning the Battersea material itself. Also I might say, too, that in the patent——

X Q. 271. I don't want you to volunteer too much, Doctor. I have you under cross examination. If you have answered my question, I will go into my next step.

A. You asked a question a while ago that I did not answer completely, and I just wanted to point out that the degree

of preference of the Battersea method over the thoria method is indicated by the sentence beginning at line 29, page 7:

"Usually, however, instead of directly adding these substances, I prefer to employ the treatment above described, of simply firing the tungstic oxide in a Hessian or Battersea crucible, for this method is simple, successful and reliable."

X Q. 272. Have you described in your direct examination just what a Hessian or a Battersea crucible is?

A. I think not. It is a fire clay crucible composed essentially of alumina and silica. Battersea and the Hessian are the same thing. Mostly alumina and silica, alumina predominating. The effect of firing the material in one of these crucibles is that the tungsten oxid at a high temperature dissolves some of the crucible material and hence the crucible material is incorporated into the oxid in that way. [fol. 94] X Q. 275. What is that material of the crucible which is incorporated in that way?

A. Mainly alumina and silica as a secondary substance.

X Q. 276. Now, as I understand your testimony with respect to the patent in suit, although the patentee did not know and hence did not state why the addition of the alkaline silicate material produced sagless filament, as I understand your testimony, it is that it was the addition of this additional material that affected or controlled the grain growth so as to bring about the sagless filament, is that right?

A. Yes, the addition of it in a special way.

X Q. 277. And does the patent state quantitatively how much of this additional material is to be added?

A. It states how much is to be added, but it does not state how much remains in the oxid.

X Q. 278. It does state, doesn't it, that analyses have shown that the percentage of the material which is added plus any other non-metallic material present is below two-tenths of one per cent and in many cases below one-tenth and even one-twentieth of one per cent, is that right?

A. Yes, that is in the final ingot after the high temperature treatment.

X Q. 279. I call your attention to the Coolidge process, but

before I do that, let me ask you this: In the absence of an explanation as to why that phenomenon occurs when the proper amount of outside material is added, in the manner specified in the patent, any one who adds this outside material in the proper quantities and in that way will inevitably produce the product produced if the specification of the patent in suit were followed? Do you agree with that?

[fol. 95] A. That is correct, if the additions are made at the right stages in the process and if the steps are carried on as described in the patent.

X Q. 284. Now, as I understood your direct examination the crystalline structure of Pacz' filament, which enabled it to resist the sagging, was that the crystal extended completely across the filament, is that right?

A. Coarse crystals, at any rate.

X Q. 285. Coolidge states that by using the Battersea crucible he obtains a coarse crystal, doesn't he?

A. No, he obtains only a fairly coarse crystal in the tungsten oxide powder, but he states at a later time that the object of these additions is to retard crystallization in the filament. That is at page 6, line 118, wherein occurs the following statement:

"It may be that 'offsetting' a phenomenon which as above explained is characteristic of some drawn wire lamp filaments, is due to the crystallization of the metal and the segregation of impurities, whereby spots are developed at which this side slipping or offsetting occurs, and that the presence of the additions introduced from the Hessian or Battersea crucible retards or interferes with the diffusion of such impurities and thus retards crystallization."

So that the coarseness referred to on page 2, line 75, is merely the coarseness of the tungsten oxide powder, and has nothing to do with the coarseness of the crystals in the finished filament.

[fol. 96] In fact, the rule is that the coarser the powder so produced, the finer the crystal in the filament.

X Q. 286. What causes the coarsening of the crystal in the Pacz patent in suit, is it the addition of alkaline silica?

A. Yes, at least that promotes grain growth when it is added in a certain way.

X Q. 287. And is alumina silica an alkaline metal?

A. No.

X Q. 288. What is it?

A. Alumina is a non-metallic substance which is neither acid nor alkaline.

X Q. 289. It is neutral?

A. It is neutral and so is silica. Neither aluminum nor silicon is an alkaline metal.

X Q. 290. What other ingredients are there on analysis in a tungsten filament of the Pacz type, besides tungsten and silica?

A. I don't know.

X Q. 291. You have never analyzed it to find out?

A. Yes, but there is so little material other than tungsen remaining in the filament that it is very difficult to get an idea of what is there and how much of any other substance besides tungsten. The spectroscope shows that in the Pacz filament silicon is present and also potassium.

X Q. 292. Now, in your direct testimony you also referred to the Langmuir patent generally.

Mr. Clark: He just referred generally to the Langmuir lamp, but I do not think he referred to the patent, Mr. Darby.

X Q. 293. Well, the patent in suit refers to it. Are you familiar with the Langmuir patent?

A. Yes, sir.

[fol. 97] Mr. Darby: I ask to have the Langmuir patent. No. 1,181,059 marked for identification.

(Marked Defendants' Exhibit B for identification.)

Mr. Clark: If your Honor pleases, in order to try to shorten this, it seems to me to be going a little far to examine this witness on cross examination in respect to a patent with respect to which he was not questioned on direct examination. Because of that I raise an objection.

The Court: Can you wait on that, Mr. Darby?

Mr. Darby: Logically, your Honor, it is part of my case at this time.

This witness has gone on the witness stand to testify as an expert on this patent in suit and has advanced opinions based on that. The patent itself refers to a prior patent of Langmuir.

The Court: That is the only reason I will allow you to question him on it. It is referred to in the patent in suit.

X Q. 294. This is the Langmuir patent for the gas-filled lamp, is it not?

A. Yes.

X Q. 295. Now, the filaments of this patent are shown as coiled—I refer you to Fig. 2. Is there a coiled filament in both Fig. 1 and Fig. 2?

A. I would have to go to the specifications to find out.

X Q. 296. Fig. 2 and all of the rest, except Fig. 1, are coiled filaments. Were these lamps sold commercially with coiled filaments in substantial quantities prior to the inven- [fol. 98] tion of the Pacz patent in suit?

A. They were sold in large quantities or substantial quantities prior to the manufacture of the Pacz invention.

X Q. 297. That is, were they sold prior to 1917?

A. Yes.

X Q. 298. In substantial quantities?

A. Yes.

X Q. 299. What type filaments did they employ?

A. Coiled filaments.

X Q. 300. Made of what?

A. Thoriated tungsten wire made by the Coolidge process.

X Q. 301. Did the General Electric Company ever manufacture and sell commercially lamps made with filaments made under the Battersea process of the Coolidge patent?

A. Yes.

X Q. 302. In substantial quantities.

A. Yes.

X Q. 303. Were any filaments employed in a coiled form, made in accordance with the Battersea process?

A. I cannot say of my own knowledge.

X Q. 304. You don't know? What were the character, the physical character of the filaments made in accordance with the Battersea process under the Coolidge patent, that were, to your knowledge, sold?

A. Such filaments were very much like the thoriated tungsten filaments.

X Q. 305. Used in the whole line of lamps?

A. Yes, they were used largely in the vacuum lamps in the earlier days of the drawn tungsten filament.

X Q. 306. And were they both the hairpin type and the coiled suspended type?

A. Well, mainly the so-called draped filament, or spider-webbing mounting.

X Q. 307. Was that a coiled filament?

A. No, that was a straight wire filament.

[fol. 99] X Q. 308. Am I correct in understanding that the coiled type of filament preceded the introduction of the gas-filled lamp commercially?

A. Yes, it is my understanding that some coiled filaments were used prior to the introduction of the gas-filled lamp.

X Q. 309. And when was the gas-filled lamp or the Langmuir type of lamp introduced commercially?

A. I think it was in 1913, or thereabouts.

X Q. 310. Again referring to the Pacz patent in suit, in producing the plaintiff's commercial lamps, is the metal filament given any treatment of any kind or nature whatsoever after it has been drawn down to its filament size, before it is put in the lamp and subjected to its flash aging test?

A. In nearly all of the lamps made, the answer to that question is no. Except that all of the coils are cleaned at a high temperature in an atmosphere of hydrogen, but the temperature used is not high enough to materially change the grain structure of the filament. Now, a few lamps are made in which it is desired to set the filament position quite accurately in the lamp and certain of those are heated to a somewhat higher temperature before the coil is mounted in the lamp, but the great mass of lamps put out commercially have no other heat treatment that modifies the crystal structure except that which they receive in the lamp itself.

[fol. 100] Met pursuant to recess at 10:30 a. m.; present as before.

ZAY JEFFRIES, resumed the stand.

Cross-examination (continued)

By Mr. Darby:

X Q. 311. Dr. Jeffries, in the manufacture of your commercial lamps, these five billion that you have made reference to, in your present practice, just how do you flash and age lamps? Just describe minutely that process, will you?

A. The filament is mounted on its supports, sealed into the bulb, the bulb evacuated for vacuum lamps, filled with gas for gas-filled lamps, and the connections made between the lead-in wires and the base of the lamp.

The lamp is then complete with the exception of so-called flash-ageing. Flash-ageing is usually carried on automatically in such manner that the current is turned on to the filament first at a voltage considerably below that at which the lamp is designed to operate.

Then, the voltage is gradually increased at successive stages in the flash-ageing until a voltage approximating 115 per cent. of the normal voltage is finally reached. A few seconds burning at each step is usually sufficient in the flash-ageing operation.

X Q. 312. What is usually the entire length of time of treatment in making the commercial General Electric lamps with the Pacz filament as they are made and sold today?

A. A matter of a few minutes at the outside.

X Q. 313. In that respect, the flash-ageing that you actually employ in the production of your commercial lamps [fol. 101] differs from the procedure described in the patent in suit, page 2, line 97 and following, where it describes running the lamp at 30 volts for two minutes, then, at steps of five volts each for two minutes up to 60 volts, and after this, the wire is run at 115 per cent. voltage for 15 minutes, making a total treatment, if my mathematics is correct, of 30 minutes, is that correct?

A. Yes, the flash-ageing is done commercially in a good deal shorter time than the schedule described in the patent. The temperature schedule is of the same nature, however.

X Q. 314. At our last session we began to cover the paragraph on page 1 of the patent in suit, beginning line 89: And do you in your commercial process use sodium carbonate?

A. No, not at the present time.

X Q. 315. Do you in your commercial process use potassium carbonate?

A. No, I think not.

X Q. 316. Do you in your present process use sodium nitrate?

A. I think not.

X Q. 317. As I understand your direct testimony, Dr. Jeffries, this sagless effect, in your opinion, is obtained by this growth of the crystal as well as its overlapping of one crystal with respect to another, is that correct?

A. Yes, it is obtained by producing a crystal of large size.

X Q. 318. If, for example, you produce a crystal of such a large size that it extends entirely across the diameter of the

filament, and just a single crystal constitutes this filament itself, you would have neither offsetting nor sagging, is that correct?

A. That is correct.

X Q. 319. In other words, a single crystal filament would be a non-sagging filament in the sense that non-sag is used [fol. 102] in the patent in suit?

A. So far as that particular property is concerned, yes. And it likewise would be a non-offsetting filament. I am familiar with the so-called crystal filaments. A single crystal filament is not a practical device. If a lamp was made with a filament of a single crystal, that would be a lamp with a filament which would not sag or offset.

X Q. 324. Do you know, notwithstanding your testimony that in your opinion a single crystal filament is not a practical device, do you know whether or not it was produced commercially, single crystal filament lamps?

A. Yes, it was.

X Q. 325. When?

A. To my knowledge about 1919.

The name of the process was Pintsch. Schaller was the patentee of the process. It was the Pintsch Company in Germany that had ownership of the Schaller patent, as I recall it.

X Q. 328. You testified in the case in Delaware involving the Coolidge patent, about the Pintsch or Schaller lamp, did you not, Doctor?

A. Yes.

X Q. 329. And you stated, in answer to cross-question 130: "Was that a proces which went into commercial use?"

And your answer was, "I think it was."

The next question was: "By whom?" And the answer: "In commercial use by the Pintsch people in Germany, perhaps about 1916 to 1920, something along there."

Then cross-question 132: "What was the product used for, if you know?"

And your answer was: "The product, I believe, was used for electric incandescent lamps."

[fol. 103] And the question: "Filament for the lamps?"

And the answer: "Filament for the lamps, yes."

You so testified, did you not, Doctor?

A. I presume so.

X Q. 330. You don't question it?

A. No. I wish to say now that the first Pintsch filaments that I ever saw were after the world war so that I am sure it would be about 1919.

X Q. 331. Would you recognize a Pintsch filament, if you saw one?

A. I think so.

X Q. 332. Do you identify those filaments which I hand you as Pintsch filaments?

The Court: Do you want to bring it over to the light, Doctor?

The Witness: I think it is sufficiently light here, your Honor.

Those filaments appear to have the characteristics of the Pintsch filament.

Mr. Darby: Would your Honor care to examine a Pintsch filament?

The Court: Yes.

Mr. Darby: I ask to have the tube of filaments examined by the witness marked for identification.

(Marked Defendant's Exhibit C for identification.)

X Q. 333. Now, Dr. Jeffries, in examining that filament to determine whether or not it had the characteristics of a single crystal filament, I noticed that at various points and places on the filament you pressed your finger nail against it and bent the filament. Is that comparable to what is known as knife test for testing the ductility of a filament?

A. Yes, in a crude way.

[fol. 104] X Q. 334. Will you please explain what is meant by a knife test, and its purpose?

A. That was a test sometimes applied to filaments to find out how brittle they were. If the filament would break easily before taking a slight bend, it was considered to be quite brittle; and if it would take a slight bend before it broke, or a considerable bend, it was considered to be tough and even sometimes called ductile.

X Q. 335. It likewise determines the length of the crystal. It is used to determine the length of the crystals that are formed, is it not?

A. No, not in any exact way.

X Q. 336. For example, if the knife edge happened to fall at a point where two crystals were abutting each other, the filament would break, wouldn't it?

A. It would be apt to, yes.

X Q. 337. Referring to the claims in suit and using claim 25 as illustrative, there is an expression in the claims, describing the grains, namely, grains of such size and contour as to prevent substantial sagging and offsetting. What is the size and contour necessary to prevent substantial offsetting and sagging?

A. The size of the grains in a Pacz filament will depend to a large extent on the diameter of the filament itself, and in the ordinary filament, used for house lighting lamps and so forth, the grains extend across the entire cross-section of the filament, at least many of the grains do.

The Pacz filament is characterized also by having a grain which is relatively long as compared with its diameter. So that the grain size may be described in general terms as those which extend across the full diameter of the filament and [fol. 105] are relatively long as compared with their diameter.

Now, as to the offsetting, if the grains extend across the entire diameter at no part of the cross-section and at no time during the life of the lamp, offsetting could not occur. So that the offsetting feature of the Pacz type of coarse grain filament is one in which the grain contours are such that side slipping is resisted to such an extent that it is not possible or does not take place in the filament during life.

That contour is usually characterized by boundaries between grains which go across the filament at a considerable angle to the plane at right angles to the axis of the filament. The boundary, itself, however, seems to have a sort of roughness, which also seems to resist the slipping action.

X Q. 338. Now, does the patent specification, anywhere in it, from beginning to end, state what is the necessary size and contour of the grains to prevent sagging and offsetting?

A. In general terms, yes.

X Q. 339. Please point out the specific page and line in each instance in the patent specification where it gives any definition of the necessary size and contour of the crystal grains to prevent offsetting and sagging—page and line, please, Doctor.

A. Page 1, line 60.

X Q. 340. The next one?

A. Line 61—line 62——

X Q. 341. The next one?

A. Those three lines state that the—

X Q. 342. Doctor, please, will you just answer my question on this point now. I am just asking you for the page and line number, and then I will give you any opportunity [fol. 106] to make any explanation you want.

A. Lines 63, 64 and 65.

X Q. 343. That is lines 60 to 65, inclusive. Any more?

A. Lines 48 to 53, inclusive.

X Q. 344. What page?

A. Page 1 of the patent in suit.

X Q. 345. Page 1, lines 48 to 53, beginning with the word "when"?

A. Yes.

X Q. 346. Lines 48 to 53?

A. Yes.

X Q. 347. All right. Any place else?

A. I think that's all.

X Q. 348. And those passages that you call attention to are the ones which in your opinion define the size and contour necessary to prevent sagging and offsetting, is that right?

A. Yes.

X Q. 349. Now, is it your testimony that all of the Pacz filaments made by the General Electric Company, in its ordinary run, produces sagless filament?

A. A filament which has non-sagging and non-offsetting properties.

X Q. 350. Throughout its entire length?

A. As mentioned before, all filaments sag somewhat, filaments may sag more under certain conditions of construction than other conditions of construction, but the filament which is made by the General Electric Company and labeled "218 filament" is a filament which is substantially non-sagging, as the term is known in the art.

X Q. 351. I gather from your last answer that when you sell this filament to your lamp licensees, you sell spools of the filament labeled "218 filament"?

A. That's correct.

X Q. 352. I notice in your testimony, for example, in answer to question 119 at page 97 of the record, you made reference to some filament as "a good grade of 218 filament." [fol. 107] From that do I gather that you get varying grades of 218 filament?

A. Yes.

X Q. 353. They vary with each other in what respect, in their physical characteristics?

A. Some of them are a little less degree of non-sagging than others, and I suppose, generally speaking, no two spools of filament would be exactly alike.

X Q. 354. Even though they are produced by exactly the same process?

A. That is correct. The same with most commercial products.

X Q. 355. Then, as I understand you, some of the so-called Pacz 218 filament sags more than others produced in exactly the same way?

A. Well, produced in a commercial way, different filaments will test a little differently.

X Q. 356. As a matter of fact, you do test filaments for sag by a device which is actually utilized to measure the amount of sag, don't you?

A. That is correct.

X Q. 357. What is that device and describe how that works, will you?

A. We mount the filaments of a certain size in the form of a hairpin, and set the hairpins in a horizontal position and pass current through the hairpin so as to heat the tungsten to a very high temperature, in an atmosphere of hydrogen.

We allow the filament to burn in that position for five minutes. Then, we have a measuring device which determines the position of the very tip of this filament before burning and after burning.

X Q. 358. Is that measuring device calibrated?

A. In terms of sag, no.

X Q. 359. In linear measurement or any kind of measurement?

A. Yes, in millimeters.

[fol. 108] X Q. 360. So that you can determine accurately in millimeters just how much sag there has been, is that right?

A. Yes.

X Q. 361. And that is the usual way in which you handle and test and analyze sag, isn't it?

A. Yes, outside the lamp. That is, this is not a lamp. We refer to degree of sag in terms of millimeters, as measured by this device.

X Q. 363. And when you are measuring sag of the filament is the filament disposed in the same position relatively that it would be disposed of if it were in the filament of an actual lamp?

A. No, the sag test is performed on a rather long hairpin and on a straight filament rather than on a coiled filament. So far as its position is concerned, it is not the same as the position it assumes in the lamp in normal use. These hairpins are mounted in the horizontal position always. That is, the hairpins are mounted in a horizontal position always for the test.

X Q. 367. Your lamps in normal use are intended to be inserted vertically, either depending down or extending upward vertically, are they not?

A. No.

X Q. 368. Your commercial lamps?

A. No, they are made to burn in any position. And that is true of all of the general run of lamps. They are intended to be used on a stationary support as distinguished from a vibrating support.

The Court: Doctor, how much of this filament do you use to make these tests, have you any idea, two, three or four inches?

The Witness: Yes, it is about four inches. Approxi- [fol. 109] mately two inches on each side of the hairpin.

The Court: And that is this wire that you finally finish before the filament is ready to go into the lamp?

The Witness: Yes, except that this test is made at a relatively large size and at only one standard size and is designed merely to test the quality of the production and test wires that are manufactured in the ordinary process of filament making. We take a portion of a wire and don't touch the whole of the wire, to tell the story of the rest of it. These four inches which we utilize in that test represents a test for about 10 or 15 miles of filament.

Mr. Darby: But a very few inches of the ingot, a sample rod of which was introduced in evidence here, will be drawn into virtually miles of the filament in its finer diameter.

The Witness: Yes, in the finest wire, that is true.

In connection with our actual measurement of sag, we have fixed as the maximum sag permissible below which the wire is rejected about five millimeters sag.

X Q. 374. So that under the Pacz wire you permit five millimeters sag—as high as five millimeters sag, and still dispose of it as No. 218 sagless filament?

A. Yes, under this particular test that I described. Anything that shows a sag over five millimeters, we do not sell in lamps, but we do not destroy it. We make this test in the early stages before we subject the metal to the working [fol. 110] process; prove it in batches before the work begins. We do not use it in lamps. If we get anything of that sort, we have to burn it. We send it through the process again. We have to utilize everything we have, but we do have to burn it back to oxid and start over again.

X Q. 377. Dr. Jeffries, I asked you while you were demonstrating the lamp, Plaintiff's Exhibit 21, if that lamp was made up special by you or for you for use in the California case, and you said that it was. I neglected to ask you the same question with respect to Plaintiff's Exhibit 22?

A. It was also made up special.

X Q. 379. And it, like Exhibit 21, does not represent the commercial type of lamp in its structure?

A. Not exactly, perhaps. It does represent, however, the general type of commercial lamp.

X Q. 380. And likewise I would like to clear this matter up on the record. This spool of drawn wire, Plaintiff's Exhibit 13, that is not Pacz wire, is it?

A. No. I think it is not Pacz wire.

Referring to Plaintiff's Exhibit 22, that likewise was made up for the California case and is not exactly like our commercial type of lamps because it was made up to quite exactly duplicate a certain Japanese lamp rather than our own. The Japanese type of lamp that was involved in the California suit. Not all of the lamps made and sold by the General Electric Company with coiled filaments now made with the Pacz wire. We still make some with the thoriated Tungsten wire. Not large amounts. They are for a particular use where the filament is subjected to bumping and shock in use and certain classes of vibration. We use the thoriated Tungsten fila- [fol. 111] ment for that purpose in preference to the Pacz filament, because the Pacz filament deforms more easily than the thoriated filament against bumps or shocks. By deforming, I mean that the filament will take a permanent set, if it is a Pacz filament, more easily under a shock than the thoriated filament will and a certain number of uses demand

that the filament withstand these heavy shocks and vigorous vibrations better than the 218 filament. The reason for this is that the fine grained structure of the thoriated filament which does permit flow, when the filament is subjected a long time to a small stress, will withstand stresses and strains of a considerable magnitude for very brief periods, whereas the Pacz filament which withstands small loads for long times without substantial deformation will deform quickly if a heavy load is applied.

The reason, I believe, is that the fine grained structure has properties simulating those of a substance like pitch. If pitch is allowed to remain on a hot day in such a position that it has some place to flow it will flow very gradually. If, however, you wish to break the pitch into particles, you can do so with a hammer blow.

Now, the fine grained material seems to have properties somewhat resembling pitch.

On the other hand, the quality of the 218 as the result of these very large crystals is one which permits movement along the so-called slip planes within the crystal itself when a large stress is applied quickly.

The Court: Will you tell us practically who uses one and who uses the other one, Doctor? The thoriated ones are [fol. 112] used by whom?

The Witness: Well, one use, your Honor, is in the New York subway, for example, where the vibration is excessive.

The Court: Is that the Coolidge one?

The Witness: That is correct. The other use is for some of the so-called mill-type of lamps where garage mechanics have a tendency to use a lamp on the end of an extension cord, and when they get through with it, they just throw the whole lamp down on the floor, with a wire guard around it. I believe we also use thoriated filaments in locomotive headlight lamps.

The Court: How about automobiles, Doctor?

The Witness: Well, they use the regular 218 filament.

The Court: Brought down to a small size?

The Witness: No. It is a relatively large filament, your Honor, because the voltage is small. Practically all other uses were Pacz 218 uses.

X Q. 394. Can I sum up, in a rather non-technical language, or will you agree with my summation that the Pacz filament is a little more brittle than the thoriated filament?

A. No, it is very much less brittle than the thoriated filament.

This 218 Pacz filament is not also known as C filament, it is known only as the 218, so far as I know. I have never heard in the Harrison plant, for example, the use of the terms B [fol. 113] and C as applied to filaments. There are those two classes of lamps, B and C lamps, but I haven't heard the designation as applied to a filament. I have never heard it as applied to wires to be used for filaments. The C lamp is a gas-filled lamp, the B lamp is a vacuum lamp. I have never heard the terms B and C applied to wires used for making filaments in the Harrison plant, for example, in the years 1921 and 1922, or thereabouts.

I have counted the grains per square millimeter in the Tungsten ingot produced in our commercial manufacture of Pacz wire. The count was all the way from a fraction of a grain per square millimeter, up to 20 or 30 thousand grains per square millimeter. The usual average is according to the treatment of the ingot. Some ingots are made to be coarse grained, in the ingots, and some fine grained. In the fine grained ingots the average is usually more than 10,000 grains per square millimeter. In the other, the average would be only a fraction of one grain per square millimeter.

X Q. 403. Am I correct in understanding, then, that the treatment in producing the ingot varies, or by the same treatment do you obtain the two results?

A. The two results are very near to one another, that is, the very fine grain goes, under certain conditions, very easily to a very coarse grain, so that sometimes the same block of metal would be partly coarse grained and partly fine grained in the ingot itself.

X Q. 404. Then I call your attention to the statement on page 2 of the patent, line 77: "The Tungsten ingots produced according to my invention usually have fine grains, as, [fol. 114] for example, between 2500 and 6500 grains per millimeter." In that respect at least, as I gather from your testimony, your commercial ingots differ from what is disclosed by the patent, is that correct?

A. Slightly quantitatively, although I may say that the fine grain structure of the Pacz ingot is usually one which is accompanied by a few large grains. And when I say that the grain size is so much at the present time, we confine the state-

ment to a fine grain area, only. Now, if one would take the whole cross-section and count in these large crystals then a different figure would be obtained.

Exhibits 20, 21 and 22 had all been subjected to flash ageing. I mean flash ageing as we use it commercially and as I described it this morning, so far as the heat schedule was concerned.

X Q. 407. That is, the treatment was in the neighborhood of two minutes' flashing and ageing; the flashing and ageing treatment was in the neighborhood of two minutes' duration?

A. Yes, or a few minutes. I think, however, these were hand aged rather than machine aged.

X Q. 408. Just one question in connection with the Hessian or Battersea crucible. Is it not a fact that the silica ordinarily, not universally, encountered in a Battersea crucible, occurs combined with sodium?

A. No, most of it surely is combined with the alumina to form aluminum silicate.

X Q. 409. Is it not a fact that the sodium is contained in the Battersea crucible?

A. There probably is a little, but the Battersea crucible is the type of product which must utilize clays with small amounts of alkaline metals, because they reduce the melting point of the crucible material.

[fol. 115] X Q. 410. As a matter of fact, Dr. Jeffries, aren't all clays used commercially a combination, I am speaking non-chemically now, a combination of silica and alumina and sodium or potassium?

A. Yes, all initial clays are.

All of the commercial lamps sold by the General Electric Company are flash-aged before they are sent out of the factory. I have examined the Pacz filament, the 218 filament under a microscope.

X Q. 429. Can you identify any of the microphotographs which I show you now as being, in your opinion, Pacz filament, or any of them as definitely in your opinion not being Pacz filament?

A. I can say that the structures are not typical of the preferred Pacz filament at any rate.

None of the photographs is typical of the preferred Pacz filament. And when I say preferred Pacz filament I mean the Pacz filament that goes into commercial use. In other

words, my answer was intended to mean that none of those microphotographs is typical of the Pacz 218 filament wire sold or used commercially by the General Electric Company for incandescent lamps.

Mr. Darby: I ask these photographs be marked for identification.

(Photographs received and marked Defendants' Exhibits H and I for Identification.)

X Q. 433. This is an etched microphotograph comparable to the etched microphotographs used on Plaintiff's [fol. 116] Exhibits 18 and 19. I ask you to examine that microphotograph of the etched filament and state whether or not in your opinion that is typical of the 218 Pacz wire?

A. No, it is not typical of the 218 Pacz wire.

I have seen structures resembling this. This is not a very clear photograph, and, of course, it shows only three sections of a coil, presumably. This is not unlike the structure which is produced at times in so-called undoped tungsten filaments. That means with no addition or no additions that modify the grain structure to any great extent. Just the pure tungsten filament. As nearly pure as we can keep it.

X Q. 438. And you have never seen that structure in the so-called 218 Pacz filament, that is, the structure shown in the microphotograph?

A. I would not say that I have not seen structures that resembled this somewhat, but I say it is not typical of the preferred product of the Pacz patent.

Again I wish to say that I do not know anything about the previous heating and mechanical treatment of the material from which that micrograph was taken.

X Q. 439. Would you be prepared to say, Doctor, that this microphotograph might have been taken from a Pacz filament?

A. No, I would not be prepared to say that it might have been.

X Q. 440. Would you be prepared to say it was not?

A. No, I would not go that far.

Mr. Darby: I ask to have that marked for identification.

(Marked Defendants' Exhibit J for Identification.)

[fol. 117] Redirect examination.

By Mr. Clark:

R. D. Q. 441. Dr Jeffries, on cross examination you were asked about clays of which crucibles are made as to whether or not clays contained certain alkalis, and you said that initial clays have some sodium in combination. What, if anything, did you mean to indicate by the term "initial as compared with the clays used in these Battersea crucibles"?

A. Clays originally formed from the slime of decomposed igneous rocks which did contain alkali metals, as well as alumina, silica and other materials as well. But I stated, I think, that the clays used for fire clay, and especially for crucibles, to be used at a high temperature are selected with reference to their low alkali content.

With reference to this hairpin testing arrangement which I described, when the metal is used in that hairpin device, it is of substantially larger diameter than the great mass of filaments used.

R. D. Q. 443. And the millimeter measurement that is taken with regard to the dropping of the apex of the hairpin represents, as I understand it, what occurs both during the initial or flash-ageing treatment and during the subsequent heating interval, is that correct?

A. No; the hairpin is flashed and the grain structure is set substantially, and then it is straightened out and positioned to a certain mark on the scale and then the real sag test is begun.

R. D. Q. 444. You were asked on cross examination to point to the pages and lines of the specification of the patent in suit with reference to the size and contour of the fila-[fol. 118] ments, and Mr. Darby said that you should just give the lines, and then you would be given an opportunity to make any explanation that you wished. I think that he neglected thereafter to give you an opportunity to make any explanation. I do not know whether you wish to or not, but if you do, you may do so now.

A. I should like to point out that that sentence beginning line 48 states that his metal, when the grain growth takes place, is of such nature that there is a marked effect on the shape and size of the tungsten grains. Now, of course, the

size of the tungsten grain has reference to grain size and the shape of the tungsten grains has reference to contours.

Then in line 60, the patent teaches that the object is to obtain coarse grains. As pointed out on Friday, the patent teaches that that coarse grain should be produced quickly in the filament after it is heated up, so that I should say that a grain coarse enough to substantially eliminate sag is taught in this part of the patent.

Finally, the shapes or contours of the grains are inferred from the prior art knowledge of what caused offsetting, as indicated by the statement that the coarse-grained filament produced by his invention does not offset.

Previously it was known that fine-grained filaments would not offset, but it was thought that coarse-grained filaments would offset, and it was thought that it would offset when the crystal boundaries extended across the full diameter of the filament and were in a plane substantially at right angles to the axis of the filament, so when the statement is made in the patent that his coarse-grain filament will not [fol. 119] offset, he teaches that the coarse grains must have such contours that offsetting cannot take place. Even though they extend clear across the filament.

I was handed a filament, Defendant's Exhibit C, and asked whether or not I could identify that as a single crystal filament. I cannot say, from visual examination. I merely say that the filament appears to be of the Schaller or Pintsch type.

R. D. Q. 447. You have stated in cross examination that you did not consider the single crystal filaments practical commercially.

A. Yes.

R. D. Q. 448. You state also that it had been used commercially to your knowledge. Have you anything further that you wish to say on those two points?

A. Yes, the filament, when made and mounted in the lamp had some very good characteristics.

One of the main difficulties was the manufacture of such a filament with certainty and economically.

Another difficulty was the production of such a filament of uniform size, so that lamps could be made with predetermined voltages.

Another was the difficulty of getting the crystals of sufficient length, and another was the difficulty of forming the filaments into close coils after they were made, and finally the filament had the disadvantage of deforming to a greater extent even than the Pacz filament, when the lamp was subjected to bumping. We attribute that now to the fact that in part there was no fibrous and resilient structure near the lead-in wires in the Pintsch filament to help resist these vibrations and bumps.

So far as I know in the United States, the commercial [fol. 120] sale of Pintsch filament lamps was confined to some miniature lamps,—particularly the Christmas tree type of lamps. There were some very large lamps submitted for my attention ten or twelve years ago, constructed of such filaments, but they were sample lamps, and so far as I know were never sold in this country.

R. D. Q. 449. So far as you know, are single filament crystals now being used commercially?

A. Not that I know of.

R. D. Q. 450. During your cross examination your attention was called to a portion of the patent in suit beginning at page 1, line 89, and you were asked, I think, whether in the present commercial production of the Pacz 218 filament the General Electric Company used sodium carbonate, potassium carbonate and sodium nitrate, and I think you said that it did not use those particular salts, is that correct?

A. That's correct.

R. D. Q. 451. But do they use sodium salts and potassium?

A. Yes, they use sodium salts and potassium salts, as well as the silica. It makes no difference, so far as the ultimate grain structure is concerned, this difference in the particular potassium salts and sodium salts used.

The change from the carbonates and nitrates to the new salts of sodium and potassium makes no difference in regard to the ultimate grain structures.

Non-sag filaments can be produced by using the alkaline metal salts, and the silica in different combinations, provided they are intimately mixed with the oxid prior to reduction.

The shortening in the flash-ageing operation, to which I referred, makes very little difference with regard to grain

[fol. 121] growth during that operation. The schedule described in the patent is a little surer and perhaps preferable but the nature of the metal is such that the shorter schedule can be used with good commercial results.

In your cross examination you testified:

"X Q. 156. Now, let me put the next question which I think will complete the subject. If the lamp, after flashing, had its filament in a substantially horizontal position, as shown by the second photograph from the bottom, Plaintiff's Exhibit 18, and it assumed the position as shown in the second photograph from the bottom to the left, Plaintiff's Exhibit 16, during its normal operating life, would you say that that filament was a non-sag filament?"

And your answer was: "In the sense that the term is used in the patent in suit, I would not know without examining the particular filament and the construction of it."

And then the next question:

"X Q. 157. You cannot tell then by comparing those two filaments whether a substantial sag had occurred from the one condition to the other?"

And the answer was: "Not without knowing the size of the wire and the size of the coil and the distance between the supports, and so forth."

And then the question:

"X Q. 158. But you used these two exhibits, did you not, to illustrate to the Court the comparison between a non-sag filament and a sagging filament?"

And your answer was: "That is correct, one of them showing practically no sag, and the other one a considerable amount of sag, changing from not the straight but upward [fol. 122] bowed position to a downward bowed position in approximately 11 or 12 per cent of the life of the lamp. Furthermore, the sagging one continuing to sag, with additional burning, and the other one remaining substantially in its original position as the burning was continued."

And then the question:

"X Q. 159. I presume that if I added to my question"—and I presume that counsel is referring to cross-question 156—"that the lamp had only been burned 115 hours and it assumed this position from a substantially horizontal position, you still could not tell me whether or not that was a sagging filament?"

And your answer was: "Yes, if it sagged gradually throughout the 115 hours, it was a sagging filament."

Now, as I read that, it seemed to me there was a little hiatus between your first answer, that is, your answer to cross-question 156, and your answer to cross-question 159, in that in your answer to cross-question 156 you said that you could not tell without knowing certain other facts, whether the lamp with a filament which sagged from this horizontal position of the lower photograph of Exhibit 18, a filament having that position after flash-ageing, and sagged to the position shown in the corresponding photograph on Exhibit 16, was a sagging filament—whereas, in answer to cross-question 159 you said it was if it occurred after 115 hours. Is there any explanation that you wish to make of that?

A. In the first place, X Q. 156 refers to "its normal operating life," whereas X Q. 159 refers to 115 hours or, say, 11 or 12 per cent of the normal operating life of these ex-
[fol. 123] hibits which I showed, but I should like to clarify the answers to X Q. 156 and the succeeding several questions in this way: That a filament might be aged so that a coil is in the vertical position at the time of ageing and it would not show any bending of the coil as a whole. Then, if the lamp is burned in such manner that that coil is in the horizontal position, that coil might sag some during the life of the lamp.

If all the conditions are the same, however, as those described in Plaintiff's Exhibit 16 and Exhibit 18, I should say that the answer to X Q. 156 should be "Yes," that the filament is a sagging filament, if it assumes that much change in 115 hours burning, during normal life.

Recross-examination. By Mr. Darby:

R. X Q. 457. It is a fact, Dr. Jeffries, is it not, that the General Electric Company always flashes its lamp, with the lamp in horizontal position?

A. The lamps are nearly always flashed in the base up position.

R. X Q. 458. With the filament in a horizontal position?

A. In the ring type of construction, the filament is in the horizontal position during the normal flash ageing process.

R. X Q. 459. If there is any doubt in your mind as to whether or not the Pintsch filaments that I showed you, and which have been marked Defendant's Exhibit C for identification, are in fact or are not single crystal Pintsch

or Schaller filaments, please feel at liberty to help yourself to some of them and examine them more carefully, if you desire. What potassium salts does the General Electric [fol. 124] Company actually use in the manufacture of the lamps?

A. Potassium chloride and potassium silicate.

R. X Q. 460. What sodium salts does it use?

A. Sodium chloride and sodium silicate.

R. X Q. 461. You mean they use sodium chloride and sodium silicate or do they use one or the other?

A. Well, I think they use both. Both at the same time.

Mr. Darby: That is all.

(Witness excused.)

Gorton R. Fonda, called as a witness in behalf of the plaintiff, being first duly sworn, testified as follows:

Mr. Neave: Your Honor, before proceeding with Dr. Fonda's testimony, I would like to read into the record a further stipulation in this case.

The Court: Very well.

Stipulation as to Certain Testimony

Mr. Neave: It is stipulated that Arnold C. Kish, if called as a witness on behalf of the plaintiff in this cause and being duly sworn, would depose and say that he is purchasing agent for Uni-flow Manufacturing Company, Erie, Pennsylvania, and in June, 1935, he ordered on behalf of said company a lot of incandescent electric lamps from defendant, the Wabash Appliance Corporation, that in said month he received from the latter four packages which, from the markings thereon indicated that they con- [fol. 125] tained the lamps listed in the Wabash Appliance Corporation invoice, dated June 18, 1935.

At this time I offer the invoice in evidence.

(Marked Plaintiff's Exhibit 27 in evidence.)

Mr. Neave: The stipulation continues: And that he turned over to Alfred L. Maul of the Incandescent Lamp Department of the plaintiff, General Electric Company, said packages unopened and just as they were received by said Uni-flow Manufacturing Company, and that the

amount of said invoice, now Plaintiff's Exhibit 27, was paid by check.

It is further stipulated that if Alfred L. Maul were called as a witness in behalf of the plaintiff in this cause and being duly sworn, would depose and say that he received the above four said packages of lamps from the Uni-flow Manufacturing Company, unopened, as stated by Mr. A. C. Kish, and on opening the packages he found the lamps therein to bear the trademark "Waco" on the bulb and be contained in individual wrappers bearing the name Wabash Appliance Corporation as well as the trademark "Waco." That accompanying this stipulation are two 25 watt lamps of that purchase, one clear and one frosted.

At this time I offer the two lamps in evidence.

(Received and marked Plaintiff's Exhibit 28 and Plaintiff's Exhibit 29 in evidence.)

[fol. 126] Mr. Neave: That on July 10, 1935, and again on June 6, 1936, he shipped some of said Wabash lamps to Dr. Gorton R. Fonda of the Research Laboratory of the General Electric Company at Schenectady, New York, to be tested, and he, Maul, marked each of said lamps so shipped to Dr. Fonda with the numerals 66 in black etching ink upon the brass base.

Direct examination. By Mr. Neave:

I live in Schenectady, New York. I am a research chemist for the General Electric Company. I am a graduate of New York University with the degree of bachelor of science, and I have also from that institution a master's degree, both for the study of physical chemistry.

In addition, there were a couple of further years spent abroad in obtaining the doctor's degree, again in physical chemistry.

I have been employed with the General Electric Company since about 1910, and during that time, I have been concerned very largely with problems having to do with Tungsten incandescent lamps.

It has involved the study of the characteristics of lamps and also the chemical and physical characteristics of filaments and their crystalline structure. For instance, I have had personal experience with various chemical tests as applied to Tungsten filaments and with the determination of

their crystalline structure, both by direct examination of their surface with a microscope and also through the preparation of micro-sections and the taking of photomicrographs. I have heard the stipulation read into evidence. [fol. 127] Mr. Maul sent me two lots of 25 Watt Wabash lamps on July 10, 1935, and June 6, 1936. I received these lamps. They had an identification mark consisting of a numeral 66 written in black ink on the base. The material of the filaments of these lamps was Tungsten. It was not squirted Tungsten but drawn Tungsten.

Q. 12. State whether or not these filaments contained more than three-quarters of one per cent of non-metallic material?

A. The filaments contained substantially no impurities whatever, so far as I could determine, either metallic or non-metallic. They were vacuum lamps.

Q. 14. Did you make any tests to determine whether the filaments sagged after burning?

A. Both types of lamps, the clear and the frosted, were free from development of any sag occurring during operation.

I made microscopic examination of the filaments to determine their crystalline structure. I found that the crystalline structure was what might be called made up of coarse grains. The grain boundaries almost altogether are of the overlapping character. In fact, there were no boundaries whose planes would run directly across the wire in a direction perpendicular to the wire axis; at right angles to the axis of the wire. I found no offset of the filaments after burning. The surface of the filaments showed diemarks characteristic of drawn wire which had been imparted by drawing through dies. And furthermore, the portions of the filaments imbedded in the leads which had never been heated to the point of crystallization were fibrous in structure, again characteristic of drawn wire.

[fol. 128] Mr. Neave: I have here a book of photo-micrographs, which I would like to have marked for identification as Plaintiff's Exhibit 30.

(Marked Plaintiff's Exhibit 30 fo. Identification.)

These micrographs are photographs of the sections which were prepared from filaments from these Wabash lamps

sent me by Mr. Maul and include both those from clear bulbs and those from frosted bulbs.

These filaments that I examined were coiled filaments.

Turning now to Plaintiff's Exhibit 30, the sections as shown on pages 1 to 9 are sections taken of segments of a coil along a plane parallel to the axis of the filaments themselves. This can be demonstrated on Plaintiff's Exhibit No. 15, a model in copper of a coiled filament. I have had the surface of one of the coils at the end ground in the direction so described, that is, as in a plan parallel to the axis of the wire itself—as demonstrated by these first photographs now under consideration.

Segments of the coils prepared by breaking up the coil were placed on a flat copper block, a steel plate placed on top, and the whole subjected to sufficient pressure to indent these filament segments in the copper block so that their surface lay flush with the surface of the copper. The whole thing was then ground and polished in order to disclose a plane of the filament that lay near the center of the filament and thereupon etched to bring out the crystal structure.

Turning to pages 1 and 5 of Plaintiff's Exhibit 30, these [fol. 129] photomicrographs disclose sections of the filaments that were imbedded inside the pinch of the lead in the case of a frosted lamp, on page No. 1, and also for a clear bulb lamp on page No. 5.

These sections of the filament had never been subjected to temperatures sufficiently high to crystal-ize them, and the fibrous structure that they disclose is significant of their preparation as drawn wire.

At the top of page 1, the initials W. F. 1, and on page 5, W. C. 1, and that throughout Plaintiff's Exhibit 30 W. F. and W. C. appear. Those are marks which I gave to individual lamps, the W. F. standing for Wabash frosted, the W. C. standing for Wabash clear. The numeral is simply an identifying number which I gave to individual lamps. These numbers I have written on the bulbs of the lamps for further identification, if necessary.

Now, turning to pages 10 and 11, these pictures are of frosted lamp—a frosted Wabash lamp to which I have given the number WF-3, out of a lot sent me by Mr. Maul.

Because of the frost on the bulb it was impossible to see the filament with the naked eye and these photographs were prepared by passing a concentrated beam of light

through the bulb and thereby obtaining a photograph as a silhouette of the internal construction. They show the coiled filament placed in the so-called loop-back construction.

The photograph on page 10 was made of a lamp fresh from the carton. At that point it had not been burned by me at all. The photograph on page 11 is of the same lamp [fol. 130] after it had been burned on a life test, at its labeled volts. This life test was discontinued after 502 hours. At that point the filament was still intact but before the photograph was taken the lamp evidently had a bump which caused the filament to break.

One side is broken, but the photograph on page 11 nevertheless shows the segments of the filament which remained, and it is noticeable that these coils are substantially free from any sag whatever as compared with the corresponding coils on page 10. In each case the lamp was placed in substantially the same position with reference to the beam of light. I could notice no offsetting at all.

I made further tests of the filaments of this lamp WF-3. After the photograph of page 11 was obtained, the filament was removed from the lamp and sections made according to the method that has been described by Dr. Jeffries, involving sections across the coil in a plane parallel this time with the axis of the coil, so that any one picture shows a succession of coils or a succession of individual turns in the coil filament.

The micrographs shown on pages 12, 13 and 14 of Plaintiff's Exhibit 30 represent sections from this filament WF-3. The micrographs on pages 15, 16, 17, 18 and 19, have a different aspect from the ones we have examined before. These sections were made from a coiled filament which had been taken from the lamp fresh from the carton. One that had not been burned by us at all, but one which it is apparent had been flash-aged in the factory. That is a [fol. 131] Wabash lamp of the same lot received by me from Mr. Maul.

The coil filament was so pliable that it could be pulled out to a considerable extent which, in itself is indicative of very high ductility.

The photographs on these pages 15 to 19, inclusive, were prepared by taking segments of the coils which had been pulled out this way and pressing them into a copper block and then polishing and etching as before.

The pictures on pages 20 and 21 show sections from the same filament as shown on pages 15 to 19, inclusive, except that they were prepared in the other way and represent sections of the coils in a plane parallel to the axis of the coil itself.

All these photographs, by the way, with the exception of that on page 15 are of portions of the filament that include crystallized wire. The photograph on page 15 is that of a portion of the wire that had been imbedded within the lead. Its structure is that—it shows the fibrous structure of drawn wire as a consequence of not having been heated to the crystallizing temperature.

The picture on page 16 shows in this regard a segment of the coil filament immediately adjoining the lead. The upper part shows the fibrous structure of the filament that had not been heated to the crystallization point, and the lower half of the picture shows the conversion of this fibrous structure into a granular crystallized filament.

It is particularly striking as the two abut one another directly. I examined the filaments under a microscope, of [fol. 132] the various lamps, micrographs of which are shown on pages 1 to 21 of Plaintiffs' Exhibit 30, and all of the sections which I examined, as well as the surface of the wires before sections were made of them showed structures of which these photographs are typical examples.

Turning now to pages 22 to 25, inclusive, these pictures were made of a clear Wabash lamp from the same lot to which I have given the number WC-10. The pictures 22 and 23 were taken of the lamp fresh from the carton before having been burned by me at all. 22 represents about the normal size of the lamp—the actual magnification is 1.3 diameters.

The photograph on page 23 is a photograph considerably enlarged of one segment of the coiled filament held between a lead and the first of the anchors to bring out details of the coils. This lamp was then subjected to a forced life test consisting of operating for one hour at 172 volts, a 50 per cent over voltage, equivalent to about 250 hours of normal burning at its regular voltage.

The photographs of the lamp after this treatment are shown on pages 24 and 25.

Again, that on page 24 is about normal size, whereas that on page 25 represents an enlarged view of the same coil shown before burning on page 23.

By comparison of the photographs on pages 23 and 25, it is evident that there has been no sagging of this filament at all that can be detected.

Twenty-four Watt Wabash lamps were received by me from Mr. Maul. Of these I examined 16. I have the lamps [fol. 133] which I examined, what may be remaining of those lamps.

Mr. Neave: In the meantime, I would like to offer in evidence as Plaintiff's Exhibit 30, Plaintiff's Exhibit 30 for Identification.)

(Marked Plaintiff's Exhibit 30 in evidence.)

Mr. Neave: I also would like to offer in evidence the carcasses, so-called, of the lamps which were examined by Dr. Fonda. They are each marked on the outside of the carton with the lamp identification number. If the carton is broken open, the parts will fall out. Therefore, I think it would be better for these to be given a single exhibit number.

(Marked Plaintiff's Exhibit 31 in evidence.)

The Court: You mean if any one of those is opened—is the bulb defective now?

Mr. Neave: Well, the bulb had to be broken in order to take out the filament, so that there is a piece of glass, another piece of base, and so on.

Q. 43. Dr. Fonda, I show you a chart headed "Wabash," and I ask you to explain what it represents.

Mr. Neave: And I would like to offer it in evidence as Plaintiff's Exhibit 32.

(Marked Plaintiff's Exhibit 32 in evidence.)

[fol. 134] A. This chart is made up of photographs of Wabash lamps and of filaments from those lamps.

The two photographs on the left are of a Wabash lamp, the upper one being of the lamp before burning and the lower of the same lamp after burning one hour base down at 172 volts, equivalent to 250 hours at the rated value of 115 volts.

At the right, the two center pictures are enlarged photographs of the same segment of coil in the same lamp shown

on the left. These photographs are magnified 22 diameters and bring out this particular coil both before and after burning.

The photographs at top and bottom of this exhibit are of coiled filaments. The one at the top shows the crystalline structure of the filament of this Wabash lamp taken before burning as a consequence purely of flash ageing. The photograph at the bottom shows a structure developed in the filament of a Wabash lamp after 502 hours burning at its normal voltage.

The Court: Just a moment, please. This top one, you say, shows the crystalline structure before burning 500 hours. You say that is flash burning?

The Witness: Yes, because that was the ageing——

The Court: That might be a little misleading, before burning; that might mean no burning.

Mr. Clark: It means as received from the factory. Of course, he does not know what the actual——

[fol. 135] The Court: He does not know what flash ageing they subjected it to?

The Witness: I should have said, before burning by me.

The Court: Before burning by plaintiff. You don't know what the defendant did.

Mr. Neave: That is it.

The right hand top micrograph of Plaintiff's Exhibit 32 corresponds to page 21 of Plaintiff's Exhibit 30. The picture just below the one referred to shown in the enlarged view of coiled filaments before burning is shown on page 23.

The enlarged view of coiled filaments after one hour burning at 172 volts is shown on page 25.

The crystalline structure after 502 hours burning at 115 volts is shown on page 14.

The photographs on the left of Plaintiff's Exhibit 32, Wabash lamp before burning, is shown on page 22.

The Wabash lamp after burning, on page 24.

All the lamps concerning which I have testified come from the two lots of 25 Watt lamps which I received from Mr. Maul. In my examination of these 25 Watt lamps, I found no indication whatever of sagging or offsetting.

Mr. Neave: That is all.

Cross-examination.

By Mr. Darby:

X Q. 53. Dr. Fonda, in your work did you ever hear of the designations, the arbitrary designations B and C applied to wires used in filaments?

A. Yes. The designation B applied to thoriated filaments. The designation C was a factory term formerly in [fol. 136] use at the Harrison Lamp Works, applying to a wire that had essentially the same crystalline characteristics as the Pacz 218 wire.

I testified that it's the Wabash wire that I examined or at least that I analyzed, I was unable to detect any appreciable trace of non-metallic material. It was of the order of 99.99 per pure tungsten. That is another way of saying that it contained substantially no non-metallic material or other metal.

I ran some of the lamps that you tested for a period of 502 hours. That applied to one particular lamp referred to this morning. That is shown in Plaintiff's Exhibit 30, page 11. That is the only lamp that was run for a period of 502 hours.

I tested several others, including, for instance, the lamp WC-10, referred to this morning on pages 22 to 25, at a forced voltage, but the equivalent hours at a normal load was less than 500 hours. It amounted to about 250 hours.

X Q. 63. The fact that you tested some of these lamps at a forced voltage leads me to believe that you can increase the normal voltage—you can subject the lamp to a voltage in excess of its normal voltage and subject the lamp to that treatment for a prescribed period of time, and that would be equivalent, in its effect on the filament, to running the lamp at its normal voltage for a considerable longer period of time, is that correct?

A. Yes, in general it is true, but it is always necessary to use discretion in the interpretation of a forced test.

X Q. 64. You used discretion, of course, when you subjected the Wabash lamps to this forced test?

[fol. 137] A. There was no need to in this particular case because even at the 50 per cent over-voltage there was no sag produced.

X Q. 65. So that would the forced voltage cause a sag in the filament of a lamp which at a normal voltage would not sag?

A. In general the rate of sag is a function of the temperature of the filament. And consequently raising the voltage and thereby the filament temperature would increase the speed at which sagging would occur.

X Q. 67. And if the prevention of sag is effected by the large crystal structure and its overlapped relation to its adjacent crystal structure, how does the forced voltage cause sag?

A. Purely as a consequence of the decreased resistance to sag and resulting from a higher temperature change, so to speak, in the plasticity of the filament as a consequence of change in temperature. The degree of temperature bears a direct relation to voltage.

In my examination of the filaments of the Wabash lamps, I saw that they had been subjected to a flash ageing treatment. I received these lamps concerning which I have offered in evidence photographs in two lots.

The first lot of twelve lamps included six in frosted bulbs and six in clear bulbs, and those I received in June of 1935.

The second lot, a duplicate, I received in July of this year—wait a minute, I have those mixed, it is July of 1935, that I received the first lot, and June of 1936 that I received a duplicate lot.

Actually these two lots of lamps were from the same lot as purchased through Mr. Maul, and perhaps I can simplify the record by saying that lamp numbers running from one to six for the frosted and for the clear [fol. 138] lamps refer to those received in July of 1935, and those running from 7 to 12 refer to lamps received by me in June of this year.

X Q. 72. Do you recognize the photograph which I hand you marked Defendant's Exhibit J for identification as a photograph depicting an etched filament, etched in the manner that the filament was treated in order to enable you to produce the upper lot of photographs on Plaintiff's Exhibit 32?

A. Am I to understand that this is a filament? And if so, it is done in the manner of those pictures to which

you referred and the surface apparently has been etched in some manner.

X Q. 76. You have had considerable experience with microphotographs, haven't you, Doctor?

A. Yes.

X Q. 78. Can you recognize from the microphotograph of a piece of filament the crystalline structure of the filament?

A. I believe so.

X Q. 79. You have put in evidence as part of Plaintiff's Exhibit 30 a number of microphotographs showing just that, haven't you?

A. Yes.

X Q. 80. Insofar as the microphotograph that you have put in evidence as part of Plaintiff's Exhibit 30, of the defendant's filament, will you state that the microphotographs which I hand you, and which have been marked Defendant's Exhibit H, for identification, and which I tell you are microphotographs of a filament from an incandescent lamp, will you state that the crystalline structure is the same as or different from the crystalline structure in defendant's filament?

A. The photomicrographs on Plaintiff's Exhibit 30, are noteworthy as being clear cut examples of a structure that [fol. 139] I have come to associate with Pacz 218 wire, as I developed in my testimony this morning; the structure of these filaments in Defendant's Exhibit H for identification have a structure that is not capable of such clear diagnosis. It is true that the structure is coarse-grained but not to the extent of those shown in my photomicrographs, Plaintiff's Exhibit 30. I would say that the micrograph shown me by you in your Exhibit H for identification represented a border line case which might denote, for instance, the attainment of a poor 218 structure.

X Q. 82. Now, for the purposes of making a record, your interpretation of the microphotographs you have put in evidence, will you, on my copy of Plaintiff's Exhibit 30 which I have handed to you, I think, as well, on Defendant's Exhibit H for identification, outline the crystals that you have referred to in your answer mentioning a crystalline structure? And I will ask you to just draw a pencil around the contour and outline a few adjacent crystals on each drawing.

A. The picture, Mr. Darby, which you showed me from my record on page No. 8 has in the top coil a sample of a pronounced overlapping boundary around which I will draw the pencil mark (witness marks). I will mark it in ink. (Witness marks in ink.)

By comparison to that, the grain shown in figure 8 of your Exhibit H for identification, at the bottom, has a similar overlapping grain boundary, similar in shape and contour, though not in extent. The same characteristic overlapping boundary is shown in many of the other cases on both figures 7 and 8 of Exhibit H for identification.

Furthermore, it is noted that where the overlapping is [fol. 140] not so pronounced, yet the contour of the boundary does represent the level plane but has in it bends or irregularities which generally are found in 218 wire, either by themselves alone or as a consequence of the position at which the section was made. For instance, the boundary in figure 8 immediately above the grain which I have outlined in ink as it stands, goes across the filament, though in a crooked line. The section at right angles to this might show that even that particular boundary was overlapping when viewed from the other position.

(Witness marking in ink on Exhibit 30, page 8.)

X Q. 83. Now, along the same line and limited to the same purpose, referring to page 8, am I correct in understanding that the line extending irregularly from near one end of the filament through its diameter to about the middle of the section of the filament constitutes the boundary line between two crystals?

A. Yes. So that the relatively darkened portion below that boundary is one crystal and the relatively lighter portion above that boundary line is the other crystal.

In the microphotographs the individual crystals do extend the entire diameter of the filament. The boundary line between the crystals is larger than the diameter of the filament. That is true with respect to the portion of fig. 8 of Defendant's Exhibit H that I have drawn within a circle, though not to the same extent as the figure on page 8 of Plaintiff's Exhibit 30.

X Q. 88. Let me ask you, Dr. Fonda, one more question [fol. 141] in connection with subjecting the defendant's lamp to over-voltage. Is it your testimony that if you take any lamp with a normal voltage rating and subject it to an over-voltage as you did, for example, to 50 per cent over voltage, that if the filament is a sagging filament, certainly that test will make it sag?

A. That tends to aggravate or at least to hasten the sag.

X Q. 90. And that same lamp if allowed to operate at normal voltage for 1000 hours, for example, you would expect that same degree of sag would ultimately be obtained as you obtain with the over voltage short operation, is that right?

A. Yes, I would expect a degree of sag of the same order at any rate.

Mr. Darby: That is all.

(Witness excused.)

ZAY JEFFRIES, recalled, further testified as follows:

Direct examination.

By Mr. Clark:

I have heard the testimony of Dr. Fonda, and I am familiar with the photographs and micrographs which are included in Plaintiff's Exhibit 30.

Taking first the structure of the filament in the cold clamp, it can be seen on page 1 of Plaintiff's Exhibit 30, that the fibrous nature of the filament in Defendant's lamp is similar to the fibrous nature of the filament of plaintiff as shown in the two upper figures of Plaintiff's Exhibit 19. That is indicative merely of the fact that it is a drawn fila- [fol. 142] ment. The same may be said of the micrograph on page 5 of Plaintiff's Exhibit 30; also the micrograph on page 12 of that exhibit; also on page 15, and also a portion of page 16, the upper portion.

Now, with reference to the micro-structure of the filaments in the so-called hot portions, the structure is in general the same as that shown at the bottom right of Plain-

tiff's Exhibit 19, clearly contrasted with the bottom left of Plaintiff's Exhibit 19. That is, the grains or crystals of the defendant's filament extend across the entire diameter of the filament the same as in the structure of the 218 filament of plaintiff.

The crystals are relatively long as compared with their diameter in both cases and the junctions between the crystals in both cases are of such nature that offsetting could not occur. I took particularly page 2, page 3, page 4, page 6, page 7, page 8, page 9, page 13, page 14, the lower portion of page 16, all of page 17, and 18 and 19 and 20 and 21.

In my opinion, and within the meaning of the Pacz patent, the defendant's filaments, as represented by the microphotographs, to which I have referred in Plaintiff's Exhibit 30, are made mainly of a number of comparatively large grains; the grains of such size and contour as to prevent substantial sagging and offsetting during a normal or commercially useful life.

Cross-examination.

By Mr. Darby:

Mr. Darby: I would like just to test the credibility of this witness on the subject of comparing microphotographs in the manner that the witness has done.

[fol. 143] X Q. 471. Doctor, you have compared the microphotographs of the filament employed in defendant's lamps, as shown in Plaintiff's Exhibit 30, with the microphotographs of Plaintiff's Exhibit 19, and I understand your testimony to be, you find, so far as grain structure and arrangement, substantial identity, is that correct?

A. That is correct.

X Q. 472. Will you likewise compare Plaintiff's Exhibit 30, the micrographs therein shown with the microphotographs as shown, for example, in the second column, the two lowest photographs, on the sheet which I ask to have marked.

Mr. Darby: I ask to have this marked Defendants' Exhibit K for identification.)

(Marked Defendants' Exhibit K for identification.)

X Q. 472. (Continuing.) And state whether or not you likewise find substantial identity between them in these respects.

Mr. Clark: I suppose your Honor's ruling applies to this, that is, the ruling which your Honor made before, that it is merely for the purpose——

The Court: Yes, it is only to test his credibility.

Mr. Clark: Yes, he cannot prove his case through our witness.

The Court: I would mark those A, B. You had better put on the side AB, to the left of it.

X Q. 473. Just put an A and put an arrow to it. And B down below.

[fol. 144] A. If one were judging from those two microphotographs alone, in the very restricted length shown and could be absolutely assured that the rest of the length of the filament has the same grain contour and the same grain size, the two micrographs could be described as representative of non-sag and non-offsetting Tungsten filament.

X Q. 474. And you made that assumption when testifying with respect to the filament of which microphotographs are in evidence as part of Plaintiff's Exhibit 30, did you not?

A. In part only because considerably greater lengths of the filaments are available for study and furthermore the corresponding lamp tests were reported with reference to non-sag and non-offsetting characteristics.

The Court: In other words, you took other factors into consideration which were within your knowledge besides just these pictures?

The Witness: Yes, I took into consideration Dr. Fonda's testimony. I did not conduct any tests or microphotograph examination of the Wabash filament myself.

The Court: He assumed that all that testimony was true.

Mr. Darby: I do not know that Dr. Fonda testified that he examined great lengths of wire. That is the point. That is all.

Mr. Clark: That is all.

(Witness excused.)

ol. 145] ABE PARKER, called as a witness in behalf of the aintiff, being duly sworn, testifies as follows:

Direct examination.

By Mr. Clark:

I am one of the individual defendants in this case. I side at No. 283 East Fifth Street, Brooklyn. My per- nal telephone number is Windsor 6-1464. I am president the Wabash Appliance Company. The other officer of e Wabash Appliance Company is Mr. Abe Adler, the her individual defendant in this case. We two are the ly officers of the company and the only directors, and e only stockholders. The Wabash Company was incor- orated, I believe it was in 1925. Mr. Adler and I are the ly officers of no other companies. There is a subsidiary mpany occupying the same place of business as the efendant Wabash Company. The Sun-Glo Lamp Works.

Q. 14. And is it the Sun-Glo Lamp Works Company at has a sign on your place of business?

A. No, I don't think so. The Sun-Glo Lamp Company is st a sales organization.

The Court (to the witness): Is it a separate corporation?

The Witness: Yes, sir.

The Court: Who are the officers?

The Witness: Mr. Adler and myself.

The Court: And it sells the material which the Wabash ompany makes?

The Witness: Yes, sir.

The Court: Including these lamps?

The Witness: Yes, sir.

ol. 146] Q. 16. And do you and Mr. Adler own the stock the Sun-Glo Lamp Works?

A. The Wabash Appliance Company does.

Q. 17. I suppose the business is divided between you and r. Adler, and as I understand it you are the man who is charge of the selling and Mr. Adler is in charge of the anufacturing?

A. I am not in charge of the selling.

Q. 18. What are your duties?

A. Just executive work—as an officer.

Q. 19. What do you do as an officer?

A. I am inside in the office to see that everything goes along all right, I am at the executive end of it. I am the head executive of the office.

Q. 21. And do you have charge of the purchases of wire?

A. No, sir.

Q. 22. Who does that?

A. Mr. Otto Fole. He is our superintendent.

Q. 24. Does he work under Mr. Adler?

A. He works for the company—he works in the company.

Q. 25. Is Mr. Adler the production man?

A. No, I wouldn't call Mr. Adler the production man. He is an executive position, the same as I do.

Q. 27. Don't you have any division of labor between you two executives who are the only officers of the company?

A. Mr. Adler has charge, most of it in the manufacturing end.

Q. 28. And you have the office end?

A. Yes.

The Court: You pay the bills, is that right?

The Witness: Yes.

The Court: Where do you get this wire from?

[fol. 147] The Witness: We buy it from the Callite Products and the Syrian Wire & Contact Company.

The Court: Do you make any of it yourselves?

The Witness: No, sir.

Q. 29. What is the address?

A. They are both in Newark, New Jersey, but I don't know the address.

Q. 30. What is the J. J. Kermit Company?

A. That was an old sales organization. It used to sell lamps—it was part of our company.

Q. 31. Were you a principal in that company, too, you and Mr. Adler?

A. Yes, sir.

Q. 32. Operated from the same address?

A. Not from that address, from our old address on Johnson Avenue.

Q. 33. In a recent telephone book we see the J. J. Kermit Company at 335 Carroll Street.

A. I do not know; they must be still carrying the name; it happens to be the same number as the Wabash Appliance, and I presume they carried it along. The same telephone number as the Wabash Appliance Company.

The Court: What happened to that company?

The Witness: We just dissolved it.

The Court: Dissolved it regularly at Albany, or just between yourselves?

The Witness: My attorney took care of that.

The Court: Did they send papers to Albany dissolving it?

The Witness: I believe they did.

[fol. 148] The Court: So you do not pay any further State tax?

The Witness: That is right.

By Mr. Clark:

Q. 35. You do not know except you assume that is so?

A. I assume so.

Q. 36. As I understand it, the Wabash—the telephone company lists the Wabash Appliance at 335 Carroll Street, and says "If no answer, call Windsor 8-7420." What is Windsor 8-7420?

A. That is my old phone number at home, I have moved since then; it is changed to Windsor 6-1464. At that time that was my home telephone number.

Q. 38. And the Sun-Glo Lamp Company is also listed at 335 Carroll Street with the telephone number Main 4-0680, and "If no answer, call Windsor 8-7420."

A. That was after working hours when the factory closed, for emergency calls.

Q. 39. Then they were to get in touch with you personally?

A. Well, to call that number.

Q. 40. Can you say whether most of the wire came from the Syrian Company or the other company which you mentioned?

A. From Callite.

Q. 41. Most of it came from Callite?

A. I presume so.

Cross-examination.

By Mr. Darby.

X Q. 42. Has there been a period of time since when all of your wire has come from Callite as distinguished from Syrian?

A. Yes. We discontinued getting wire from Syrian about a year ago.

[fol. 149] Mr. Darby: That is all.

The Court: I would like to ask a question. Do you assemble these lamps?

The Witness: Yes, sir.

The Court: Do you make any part of the lamp yourself?

The Witness: Well, we just assemble the lamp. We get the bulb from the Corning Glass Works, it comes in a bulb form.

The Court: You get all the parts of it from different manufacturers, you do not make any of it yourself?

The Witness: No.

The Court: How many men do you employ?

The Witness: Well, we employ about 200 people at the present time.

The Court: On lamps?

The Witness: Yes.

Mr. Clark: How many?

The Witness: About 200 people.

By the Court:

Q. 45. How many lamps a month do you sell on an average?

A. On an average we sell from six to seven hundred thousand lamps a month.

Q. 46. The business averages how much per year in this?

A. I would say over a half million dollars.

By Mr. Darby:

We buy the glass bulbs just in the shape they are now from the Corning Glass Works. The Corning Glass Works is the only manufacturer of glass bulbs in the country as far as I know. They make bulbs for the General Electric [fol. 150] Company, too. Part of it, I don't know whether

they do all. They do make bulbs for the licensees of the General Electric Company under the patent in suit. And Westinghouse as well. The filament comes from Callite and Syrian, and since about a year ago from Callite. We buy the bases from the Providence Base Works of the General Electric Company, the plaintiff corporation. We buy the stem and filament parts. The tubing, the glass tubing we buy also from Corning Glass Works. We have vacuum pumps and all sorts of machinery which assemble them. We pump the air out, and when it is a gas-filled lamp we put the gas in. The bulb for the frosted lamps in its frosted condition was bought from the Corning Glass Works until quite recently. In all other respects the fabrication is the same as we covered with the non-frosted bulb. That is, we buy the base from the General Electric Company—and the filament and the wire from the Callite Company.

(Witness excused.)

Mr. Clark: The plaintiff rests its prima facie case.

Mr. Darby: I offer in evidence copy of Pacz Patent No. 1,299,017, heretofore marked Defendants' Exhibit A for Identification.

(Defendants' Exhibit A for Identification received and marked in evidence.)

Mr. Darby: I offer in evidence copy of the Langmuir Patent 1,180,159, formerly marked Defendants' Exhibit B for Identification.

(Defendants' Exhibit B for Identification received and marked in evidence.)

[fol. 151] PAUL A. KOBER, called as a witness on behalf of the defendants, being duly sworn, testifies as follows:

Direct examination.

By Mr. Darby:

My experience consisted of eleven years with the General Electric Company at Harrison, New Jersey, and also at Schenectady, New York. My experience with that company began in June, 1917, and ended in June of 1928. My

education consisted of the usual preparatory training for college and four years at Harvard, where I concentrated in chemistry and graduated in 1914 with the degree of associate in arts.

The nature of my work while with the General Electric Company was lamp engineering work. I had to do with filaments, their preparation and treatment and with research work in connection with the use of the filaments in lamps.

I was familiar with the so-called Pacz wire used as a filament in incandescent lamps. That wire was known in the laboratory while I was there as C-wire.

There was another wire that was known as B-wire which was thoriated wire. I do not know the process under which thoriated wire was made from my own experience. It was the Coolidge process. The B-wire was the Coolidge wire and C-wire was the Pacz wire. I was assigned to a particular work in connection with the Pacz wire having to do with producing a sagless filament in a lamp from May of 1923 to January of 1926. Prior to that time, I have been familiar with the Pacz wire.

[fol. 152] Q. 18. And had you examined the Pacz wire and analyzed it?

A. No, I did not. At that time I made a thorough and exhaustive study of the Pacz wire. I handled considerable Pacz wire in the way of treating it, and, of course, examining it microscopically, and also in giving it various tests after treatment.

In the course of my work in the treatment of tungsten wire and filaments I had occasion to run many tests involving many thousands of lamps in the Engineering Department, as well as in the factories. It is rather difficult to give just how much wire I actually handled.

I was started in May of 1923, on my research with Pacz wire by Dr. Saul Dushman of Schenectady, my superior. That research was directed toward bettering the Pacz wire. My problem given me at that time was to make a 100 per cent non-sag coiled filament from Pacz wire. I couldn't make sagless filament from Pacz wire by that time, May of 1923.

Q. 25. Did you examine Pacz filament wire to ascertain whether or not it, that is Pacz filament wire, as made by

General Electric Company, in commercial quantities, to determine whether or not it was sagless?

A. I examined it, and I found in running many tests and observing many thousands of lamps in those tests as well as production lamps in the factory, that—I found no lamp that didn't sag after flash ageing.

Q. 26. Were these lamps that you examined as part of your research work on this problem, were they commercial lamps put out by the General Electric Company?

A. Part of them were commercial lamps and part were experimental lamps; but the experimental lamps were essen- [fol. 153] tially the same as the factory lamps. As a result of my work I was enabled to produce a sagless filament about 1925, as I can remember it, about the middle of the year 1925.

Q. 30. Have you any contemporaneous documents that you can refer to to refresh your recollection as to the exact date?

A. I believe I can. (Referring to papers.) The exact date is somewhat off from what I have given you. I have a record here of approving the method which gave absolutely 100 per cent non-sag filament as April 4, 1924.

I made a contemporaneous report of my work to the General Electric Company.

Q. 33. What is the practice of the General Electric Company with respect to engineers like yourself who are assigned to a task of giving that task some designating number?

A. In my work I was assigned a docket number for the Patent Department, and the Docket Number was 72. I was required to make written weekly reports on the progress of my work. I made such reports. The weekly reports didn't bear the Docket No. 72, only reports that I made occasionally to the Patent Department bore that number.

The name of the man in the Patent Department to whom I made those reports was Charles McClair.

I have a copy of my report dated June 6, 1924, on the development of sag proof wire. Three copies of this report were made. One went to Dr. Dushman, one went to Mr. McClair and one for the office file. The fourth copy was retained by me.

Attached to this report is a photograph here. This photograph at the time the report was made, I believe, was un-

[fol. 154] attached; later on, it was submitted, as I recall it, as part of the report. This report and photograph have been since the time it was made and submitted by me, this particular copy, in my hands. It has been in my possession continuously except when I loaned it to counsel in this case to study. The report, otherwise, is in exactly the same condition now as it was at the time it was rendered.

Mr. Darby: I offer this original report in evidence.

Mr. Clark: Suppose you mark it for identification now, Mr. Darby? I have not had an opportunity to look at it.

Mr. Darby: I will have it marked for identification.

(Marked Defendants' Exhibit L for identification.)

In the first line on page 1 of the report I refer to coiled X wire. X wire at that time was known generally as the overlap crystal structure. That was simply a designation given at that time to it. Just an arbitrary name given to a wire which had been treated and had more or less the overlap crystal structure.

The next to the last line on page 2, reference is made to the fact that the crystals are equi-axed. By equi-axed is generally meant a crystal structure which has its axes about the same length in all directions or of the same degree. It is a condition of crystal growth that one gets in treating Tungsten wire at about 2200 degrees Centigrade.

In the middle of page 3 of this report, the statement is made, "In the B wire (Fig. 3) the presence of thoria pre-[fol. 155] vents the crystals from growing in considerable length while in the C wire (Fig. 4) there are comparatively few crystals rather long and more or less overlapped." The C wire I referred to here was commonly known in the Edison Lamp Works as Pacz wire.

On page 4 of the report at the bottom of the page, are two drawings, one for X wire and one for C wire. The drawing correctly shows the crystalline structure of the X wire as a result of my study of the Pacz wire at the date of this report. The picture on the left, the X wire shows the Pacz wire and represents the average crystal length overlap structure; in a general way, shows the overlap structure.

Q. 54. I am referring to the left hand picture.

A. The X wire.

Q. 55. Part of Fig. 5, and your statement immediately above it "The difference between the C and X wire may be represented by the following sketch."

A. Yes. This X wire is the wire after I treated it in accordance with the substance of my report. At that time it was still given the X wire designation. Later on, we call it C wire, or Pacz wire treated by my method. This X wire was Pacz wire subject to additional treatment.

The process I developed to make an absolutely non-sag filament consisted essentially in subjecting the coiled filament, Pacz' coiled filament to a very high temperature, approximately 2800 degrees Centigrade. This was done in placing the Tungsten filament in a V shaped Tungsten boat which was heated electrically to the required temperature. This boat was enclosed in a hood and the atmosphere within it was hydrogen.

[fol. 156] The V shaped boat because of its construction permitted the coiled filament to lie perfectly straight and flat so that when the heat treatment was applied, there would be no squirming or change of its form. No squirming or deformation, that is, changing of its position. The filaments remained absolutely straight. To treat these filaments to produce this non-sag, absolutely non-sag effect, it was necessary to use a certain heating schedule. I have two or three, all of which worked more or less for quite a while.

However, I found that in heating Pacz wire many lots of wire were submitted to me and did not respond to this treatment; others did. The resulting wire after treating by this method was absolutely non-sag. By that I mean that one could mount it in a lamp without any supports except those of the lead wires and make it any diameter, mandrel diameter up to 50 mils., and there would be no sag whatsoever.

The hydrogen, of course, that passed through this heat while treating it had to be absolutely free from all moisture and other impurities. The heating, of course—the degree, was controlled by proper rheostats.

The object of this process which I developed was to produce a non-sag filament that had no sag whatsoever for the primary reason for making a more efficient gas-filled lamp by means of increasing the effective diameter of the filament.

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Q. 61. Before you go further, may I ask this question? I call your attention to Plaintiff's Exhibit 18. Do you consider the filament or the section of the filament shown in the foreground of two model photographs on the right hand side of that exhibit as non-sag filament in the sense that you [fol. 157] have used that term; advising you that the upper photograph is a view of that section of the element after flash ageing only and the lower photograph is a view of the same filament after 115 hours of use. Is that a non-sag filament in the sense that you have used the term?

A. It is a non-sag filament in so far as the sag shown on those two photographs are concerned.

Q. 62. Now, had you been able to obtain from the Pacz wire that you worked with a filament that would not sag considerably more substantially more than as snown on the lower photograph after 115 hours of burning?

A. I have never been able to obtain a lamp containing a Pacz filament which did not sag more than—after flash ageing—than one shown in the lower photograph.

Q. 63. Based on your experience and your work with Pacz work, in connection with this particular problem, what is your opinion as to whether or not the filament—this filament in the lamp of Plaintiff's Exhibit 18—was made with a Pacz filament made from a Pacz wire as you were familiar with it in 1932?

A. My experience has been that I have never been able to make a lamp with Pacz wire and have no sag after flash ageing, and that is also my observation on many lamps that I have observed in the factory.

That is the Pacz wire as I knew it in 1923. I have never seen a lamp made with a Pacz filament from 1923 until June, 1924, that didn't have a substantial sag and by substantial I mean substantially greater than is shown in the lower photograph, after 115 hours of use.

[fol. 158] Brooklyn, N. Y., June 30, 1936.

Met pursuant to recess at 10:30 a. m.; present as before.

PAUL A. KOBER, resumed the stand.

Direct examination (continued).

By Mr. Darby:

Q. 67. Mr. Kober, will you please refer to the photograph which is attached to the report, and describe the lamps therein, their origin and what they purport to show?

A. In this photograph are five lamps. The three on the top part of the photograph are of the 75 watt type construction. The lamp to the extreme left on the top is designated B wire. This B wire is the ordinary serrated wire used in many lamps that the General Electric made at that time and particularly in the vacuum type.

For the purpose of showing the relative sag of B wire and C wire, I had the B wire filament mounted in the 75 Watt lamp and regular C wire filament also in a 75 Watt lamp. These two lamps, after running for one hour at 115 volts, as I recall them, gave the relative sags as indicated in these two photographs. You will see that the B wire sags a little more than the C wire. The C wire is commonly known as Pacz wire, at least, that is what I was told, that the C wire was Pacz wire.

On the extreme right is another 75 Watt lamp, which is designated C-X. That is a designation I gave to the Pacz wire, or C wire, after I gave it a special heat treatment to make it absolutely non-sag.

[fol. 159] And as you will see in this photograph, there is no sag whatsoever. In most of the reproductions it is somewhat obscure, but one can see that it is absolutely non-sag.

Those three lamps were treated simultaneously for the same period of time. The C wire in the middle lamp and the CX wire in the lamp on the extreme right were taken from a lot of filaments made at the same time, so they are the same wire, similar wires in both of them. Except that the CX wire had been subsequently treated. The filament in the lamp designated CX wire was given a high temperature treatment by a process which I developed, which made it absolutely non-sag and gave it a long overlapping crystal

structure. Those three lamps were burned simultaneously from the same current source for the same period of time.

As to the two lamps shown at the bottom of the photograph; in order to show quite well the relative sag of C wire and C wire treated by my method, I used a 20 mil. mandrel for both of them.

Ordinarily, the 75 Watt lamp—well, the 75 Watt lamp in the three photographs above, have 11 mil. mandrel, and with the supports given, it prevented sag to a great extent in the C wire lamp.

Now, in the two bottom photographs, as stated before, showing up the sag outstandingly, I had the C wire made up on a 20 mil. mandrel and also for the filament which I subsequently treated.

These two lamps in order to give a thorough test, I had these two lamps connected in series, so that the same current would go through each of them. And as I recall, I [fol. 160] started off with a voltage about, well, about 60 volts, and then I increased that voltage up to operating temperature, ordinary operating temperature of the type C lamp, and when I did so, as you can see on the photograph of the lamp to the left, at the bottom of this photograph, it sagged considerably, while the one I treated did not sag at all, showing conclusively that this treatment which is not disclosed in the Pacz patent will produce an absolutely non-sag wire regardless of whether it has any supports or not, or regardless of what the mandrel size may be. I have gone up to 50 mil. mandrel without any sagging.

The wire that I used in the lower left-hand lamp of this photograph, namely, the C-wire, that was the standard wire that was being used, the Standard Pacz wire that was being used in the commercial manufacture of lamps at that time. All of the lamps in this photograph employed the coiled filament. I likewise used this process for producing filament which would not sag with a straight wire filament. I used a process for treating straight wire which was similarly, practically the same as the Schaller process. That is, the wire was passed through a superheated zone at a certain rate of speed in an atmosphere of hydrogen.

For C-wire treated by that process I obtained also a very good overlapping crystalline structure, in other words, an absolutely non-sag wire. I used that process which I developed to produce that crystalline structure, in connection with the B-wire, the thoriated tungsten wire only to a very

small extent. I treated the thoriated wire which is commonly known as B-wire. A few tests gave me negative re-
[fol. 161] sults, the wire resulting from that treatment was brittle and could not be tested. But I had performed a few other tests which showed a non-sag structure, and also quite ductile, and gave an absolutely 100 per cent non-sag quality. I did not examine it for crystalline structure.

Mr. Darby: You concede it is Mr. McClair's signature?
Mr. Clark: Yes.
Mr. Darby: I offer in evidence the report with photograph attached, heretofore marked for identification as Defendants' Exhibit L.

(Defendants' Exhibit L for Identification received and marked in evidence.)

Q. 83. Did you execute any application for patent of this process?
A. I understand you mean the process for treating coil filaments.
Q. 84. Yes to obtain a sagless filament.
A. Mr. McClair took care of that matter.
Q. 85. Did he prepare a patent application to your knowledge?
A. Yes, sir.
Q. 86. Did you execute it?
A. Yes.
Q. 87. And swear to it?
A. Yes.
Q. 88. And deliver it to Mr. McClair?
A. Well, that I do not recall, but I do recall that I assigned over my rights to those applications which he made to the General Electric Company.
Q. 90. Do you recall executing an assignment as well as the application papers?
A. The assignment I recall, that is all. Assigning it over, signing my name to some document which gave the General Electric Company the patent right to a patent.

[fol. 162] The Court: Who is Mr. McClair?
Mr. Darby: He is the patent attorney in the Patent Department of General Electric Company, in charge of these matters. All this work was done in Harrison.

I am familiar with the procedure for applying for a patent, to the extent that you know that the inventor signs the application and swears to it. I cannot recall whether or not I took that procedure with respect to that process, my memory fails me there. I have a copy of my weekly report dated April 14th to May 5th, 1924, on this same work, the original.

This report which I have produced the original copy thereof which I have had in my possession since the date mentioned. A carbon of the original copy. And this was likewise presented and signed by Mr. McClair on June 24th, 1924.

The statement on page 3, the middle paragraph mentions C-wire or Pacz wire. That is the same C-wire or Pacz wire that I referred to in the prior report. That was a commercial wire used to manufacture commercial lamps at that time.

The paragraph at the bottom of page 6, under the heading of numeral 8: "Difference in sag between C and CX-wire after ageing in lamps. May be obtained by photometric readings on 40-watt lamp," and so forth, shows that one can measure the amount of sag of a Pacz wire when made up into a lamp of a given wattage—that is, after ageing.

The figures given in this report show that the Pacz wire—using Pacz wire in the ordinary way for a 40-watt lamp and ageing it, loses about ten per cent. of its efficiency, and [fol. 163] the way I determine that loss of efficiency is by comparing it with some similar wire, 40-watt wire which I have treated by my process which does not sag—all conditions being equal, and in ageing both the 40-watt lamp with the regular Pacz wire in it and also ageing one of the Pacz wires treated, there is a sag produced in the Pacz wire and none in the other, and by photometering these lamps one determines the loss in efficiency—that is, the lumens per watt. As the table states the lumens per watt of the treated filament in the 40-watt lamp average 10.39 and the untreated 9.37, there being a difference there of about a lumen per watt, which is approximately a ten per cent loss.

That, as I say, again is a method where one can express in figures the amount of sag in terms of lumens per watt. L. P. W. stands for lumens per watt. The watt of these lamps, as you will note, was about 40, it ran a little below, it ran 39.3 and 39.5, but that small variation between those

two will make no practical difference, so far as the results I have given.

On the first page of this report, there is a parenthesized statement, "These values are obtained by pressing down on Tungsten coils with the 53 mil. nickel rod 100 times and deducting one per cent. for each break." That is known as the knife test. These two reports were signed by me and delivered to Mr. McClair.

Mr. Darby: I offer in evidence the second report referred to by the witness.

(Marked Defendants' Exhibit M in evidence.)

[fol. 164] Cross-examination.

By Mr. Clark:

In this last report, Exhibit M, at page 6, the part to which I referred at the bottom of the page, is the difference in sag between C and CX wire after ageing in lamps. By that I mean the sag produced by ageing. That is what I meant in my testimony in referring to sag after ageing. I mean sag produced by the ageing.

In other places, I frequently refer to that as initial sag. As distinguished from the time sag.

I am familiar with the term Pacz 218 filament. My experiments in treating Pacz wire and comparing it with 218, as far as I recall, gave practically the same results, that is, taking a number of lot wires and testing them, they all seemed to respond about the same, that is, they were responsive to this overlapping treatment that I gave.

The term that we gave at Harrison was C wire. In Harrison we used the term C wire and not 218. 218 was a designation that we always associated with wire produced in Cleveland. But I understand C to be produced by the same method that the 218 wire was produced although I never investigated to find out definitely, but I always understood it to be made essentially the same as 218.

Mr. Clark: For his Honor's knowledge, these were two different plants of the General Electric Company. At the Cleveland plant they apparently called the wire 218, and at the Harrison plant it was apparently called C.

The real purpose of this treatment, of this X treatment, which I was working with was to eliminate this initial sag [fol. 165] I referred to, and also any time sag.

X Q. 122. Well, the C wire or the 218 wire was essentially a non-sag filament, wasn't it, so far as any time sag was concerned?

A. The C wire from my experience, if there were not a sufficient number of supports given to it, would also have a time sag, if the supports were insufficient; and when it was initially lighted up a sag would begin which would prevent to a certain extent the proper crystal growth or setting which it would have with normal number of supports, and therefore, there would be a time sag.

X Q. 124. You don't want to change this statement in your report, do you, on page 5, of your Exhibit L: "Although C wire is essentially non-sag wire, yet, because of the conditions to which it is subjected in the lamp, there is always more or less initial sag when the lamp is first lighted up and occasionally a time sag?"

A. There is occasionally a time sag.

X Q. 125. You do not want to change that?

A. No. As far as I know this X process of mine never went into commercial use.

Mr. Clark: I think that is all.

By the Court:

Q. 127. Do you know, you have made a study of this wire situation, haven't you?

A. I have.

Q. 128. Do you know the Coolidge patent pretty well?

A. I know the Coolidge patent.

Q. 129. You have studied it?

A. I have studied it.

Q. 130. You studied the methods by which they made wire under that Coolidge patent?

A. Yes.

[fol. 166] Q. 131. Then along came the Pacz patent, is that right?

A. That is right.

Q. 132. You have studied that?

A. I have studied that.

Q. 133. He had two patents practically, one he filed, and to all intents and purposes abandoned, is that right? The earlier patent really wasn't filed——

Mr. Darby: Yes, it was issued as a patent.

The Court: But you never used it.
Mr. Clark: Never used it.

Q. 134. Do you know that patent that was never used?
A. Yes.
Q. 135. And do you know the present Pacz patent?
A. Yes.
Q. 136. And you know your own formula?
A. Yes.

HARRY D. COWLES, called as a witness in behalf of the defendants, being first duly sworn, testified as follows:

Direct examination.

By Mr. Darby:

I reside at East Orange, New Jersey. I am presently employed by the Micamold Radio Company, Brooklyn, as chief chemist. I am a graduate of the University of Maine, with the degree of bachelor of science in chemistry, College of Engineering, and a Ph. D., pharmaceutical chemist, College of Pharmacy, and post graduate work in the University [fol. 167] of Chicago under a scholarship to obtain the degree of master of science. I completed the work for a master of science degree in the University of Chicago.

I started in at the research laboratories of the General Electric Company in Schenectady in 1905, working for Mr. Becker, working on Tungsten purification, and so forth, the process of making a Tungsten filament in the early days.

In 1905 and 1906, that was. From 1907 to 1912, I was with the Westinghouse Lamp Company in Bloomfield, New Jersey, as chief chemist in the laboratory, and assistant to Dr. Scholl, chief consulting engineer, and metallurgical work and chemical tests.

From there I went to the Independent Lamp and Wire Company in Weehawken, that is, from 1912 to 1920. The nature of my work in the Independent Lamp and Wire Company was chief chemist and technical supervisor on the purification and production of Tungsten for drawn wire filaments.

From there I was transferred to the Edison Lamp Works in Harrison, and was there from 1920 to 1927.

The Edison Lamp Works is a General Electric Company plant. From 1927 to 1929, I was with the Celluloid Company as chief chemist in charge of the testing laboratories. 1930 to 1931, I was with the Dubilier Radio Company in the Bronx, as chief chemist, and from 1932 to the present, I am chief chemist of the Micamold Radio Company. They manufacture condensers and resistors.

Q. 10. Now, with what type of filaments that were used commercially in the manufacture of incandescent lamps [fol. 168] were you familiar?

A. Why, the early squirted type we began with and Westinghouse developed a continuous forming machine, which gave continuous formed filament in greater lengths than had previously been made. Those were all squirted. Then, in 1911 or 1912, the drawn wire filament was begun and developed, and the squirted wire was dropped. Not all of the drawn filament of the thoriated Tungsten type. We had four different binders at the Westinghouse. I made those up for the doping of the Tungsten. We had thoriated nitrate solution and a lime solution and an aluminum oxide solution and a sodium silicate or potassium silicate, a water glass solution. Those four were doping solutions that we used after dropping or trying to improve on the Battersea Tungsten, which was somewhat erratic, sometimes it was good and other times not. All of these types of drawn Tungsten filament to my knowledge were used in the commercial lamp manufactured by Westinghouse Company while I was with them. I left the Westinghouse Company in the late fall of 1912.

Q. 15. And did you have charge of the actual makeup of these doping solutions that you have referred to for the commercial manufacture of lamps?

A. Yes, I actually made them myself—personally. I know personally that those solutions were used to produce filament. The filaments went into lamps that were made and sold. All prior to 1911 and 1912, that was for the drawn wire, not the squirted wire.

Q. 19. But all prior to the time you left the Westinghouse plant. Now, I am interested in the nature of your [fol. 169] work when you went with the General Electric Company in 1922. First, let me interpolate: As I understood your list of employments, you went from the West-

inghouse Lamp Company in 1912, to the Independent Lamp & Wire Company, where you remained for about eight years?

A. Yes.

Q. 20. In what respect, if any, did the manufacture of incandescent lamps by the Independent Lamp and Wire Works differ from the manufacture of lamps by the Westinghouse Company insofar as the type of filament was concerned?

A. Why, we made similar types of filament. We started in with the Battersea material, oxide reduced that to Tungsten; and trying to improve upon that, we made it up with doping oxide, with the different oxides in different solutions.

Q. 21. What dopes did you use while with the Independent Lamp and Wire Company?

A. Thorium nitrate and the sodium and potassium silicates, and tried also alumina, and lime was one of our regular ones, and then we tried other various experiments, using boron compounds and some tantalum compounds. The purpose of putting these extraneous materials into the filaments was that we wanted to get a structure that was coarser and would give you—at that time, they were developing the C lamp, that is, the nitrogen filled lamp, and they wanted a filament that would not sag, and they ran into trouble, when they began making the coiled wire filaments, having the filament sag, some lots would sag and some would not. So in trying to eliminate that and getting a real constant metal that would be true to form each time, why, we left the Bat- [fol. 170] tersea Crucible material and tried to improve upon it, by adding the different materials, other materials, to make it better.

We used the Battersea material instead of the thoriated material because that seems to give a better—did not sag and produced a filament that would stand up better in the C type of lamp.

Up to the time that I left the Westinghouse Company in 1912, I had been enabled by using the various dopes to obtain a more uniform run of commercial filaments. We had what seemed to be an improvement and showed up in the pictures that were taken at that time; the coarse crystalline structure seemed to be very much better than the fine structure that we got with the thorium.

When I started with the Independent Lamp and Wire Company in 1912, to the time I left it in 1920, there had

been an improvement in uniformity of wire as to its sagging or non-sagging qualities. We improved gradually. Of course, there was always some uncertainty, but we had arrived at quite a satisfactory product.

Q. 26. And a product which in terms of rough estimated percentages, how much of the product was sagless as compared with that part which would sag?

A. That would be rather hard to answer without something. If it did not prove to be good, why, we used it simply on B lamps; and that which did not sag we used in the C lamps, the gas filled lamps.

Q. 27. Then, as I understand you, right up to the time, 1920, you still produced the same filament?

A. We always had a test to find out. I still continued to find some that would sag. That was true right up to my [fol. 171] last connection with the incandescent lamp industry in 1927.

Q. 30. Now, I would like to take you to your work with the General Electric Company when you went with them in 1922. What particularly, with respect to the sagging of filaments, what particular task were you put to?

A. To metalography work in showing up the crystalline structure.

Q. 31. Metalography work, and that included microphotography?

A. Yes, polishing specimens, taking pictures, and showing up what the crystalline structure was.

Q. 32. Did you develop microphotographic technique with the General Electric Company and for the General Electric Company as part of your duty?

A. Yes, that is what I was assigned to.

Q. 33. What was it desired to have microphotographs of?

A. Why, they wanted to get the qualities lined up so they could see what they were getting, and that was the best way to show up the crystalline structure, by magnifying it, and then they could see just what the structure of the wire was.

Q. 34. And what type of filament were you given to obtain microphotographs of?

A. Why, we had the thoriated wire and the silicated wire, the C-wire and the B-wire.

Q. 35. Was the C-wire known to you at that time by any other name than C-wire?

A. Why, that was the common designation, C-wire, used for gas-filled lamps.

Q. 36. Did you hear it referred to at all as the Pacz wire?

A. Why, sometimes, it was supposed to be a similar thing, the same kind.

[fol. 172] I had had previous experience in making microphotographs of filaments at Westinghouse in 1912, they started a department there, and I worked there through the summer of 1912.

I have photographs, microphotographs that I took of the commercial filaments used by Westinghouse prior to my departure from Westinghouse in 1912. This is of the coil filament showing up the coarse crystalline structure, and these are two other photographs showing it doped with calcium, and showing the coarse crystalline structure which they were looking for. Those photographs have been in my possession ever since they were taken in 1912.

Mr. Darby: Unfortunately I haven't copies of these, but I will have copies made up for you, Mr. Clark, and for the Court.

I offer in evidence the photograph showing the coil filament considerably enlarged and as used by the Westinghouse Company.

The Witness: In 1912.

Mr. Darby: In its commercial lamps, a photograph taken in 1912.

(Same marked Defendants' Exhibit N in evidence.)

Mr. Darby: I also offer in evidence the two microphotographs showing the doped filament used by Westinghouse in 1912 with the calcium crystals. I ask that they be marked Defendants' Exhibits O and O-1.

(Marked Defendants' Exhibits O and O-1 in evidence.)

[fol. 173] Q. 42. Is the microphotograph Defendants' Exhibit N taken from the same filament that the other two photographs, Exhibits O and O-1, were taken?

A. No, I do not think it is.

Q. 43. Do you know the ingredients of the coil wire filament?

A. This was some of the special silicated dope.

Q. 44. It was silicated?

A. Yes.

Q. 45. Doped with a slicate?

A. Yes.

Q. 46. When you say it was a special, do you mean to imply it was not their commercial wire?

A. All those lots that we run through were more or less special. They were just beginning, in 1912, just beginning to make up this doped material with the sodium and alumina and calcium and silicate. Those were the four dopes that were used at that time in 1912.

Q. 47. And used commercially?

A. In all their production of drawn wire. They went into commercial lamps that were sold.

Mr. Clark: Try not to lead this witness too much, he is a fact witness.

Mr. Darby: All right.

Q. 49. Will you very briefly explain the crystalline structure in the exhibits, Defendants' Exhibits O and O-1, with respect to their effect on offsetting or sagging?

A. Why, this coarse crystalline structure seemed to work out better on the non-sag wire, so for that reason they continued the experiments, and thought that was working on the right line when they put in material that would produce a coarse crystalline structure in place of the fine crystalline structure. And these were some of the first lots made in 1912 with coarse crystalline structure.

[fol. 174] The irregular sets of the crystals in their overlapping position prevents this point of non-drooping and sagging of small crystals, this coarse crystalline structure, in that the crystals are interlocked and the wire does not sag as it does with the very fine crystals where the crystals will slide over one another and droop down when the crystals are not interlocked.

Defendants' Exhibit N shows an early coil filament, this is taken after it has been burned, showing the crystalline structure, and this is part of—this half here (indicating) shows the structure quite plainly. It is in a little better focus. The other is dark and does not show it up. The coarse crystalline structure shows on the whole surface. On the left. Over here, of course, this is out of focus and does not show it (indicating). I refer to the darkened side of the photograph. The lighter side shows the coarse grain better.

The Court (to witness): What about offsetting? Do those pictures that you have just examined, take those, what about this doctrine of offsetting?

The Witness: That prevents offsetting, that is one of the reasons why we started in doping the tungsten. You got that coarse structure, and that prevents both sagging and offsetting.

Q. 57. And when you went with the Independent Lamp & Wire Company, did you likewise make microphotographs of the doped filaments that they were using in their commercial lamps?

A. Not at first, not until later on. In the latter part of [fol. 175] the time. The latter part of the term of my employment by the Independent Lamp & Wire Company in 1920.

Mr. Clark: May I interpose here? That is long after the date of the application of the Pacz patent, and therefore it is immaterial.

Mr. Darby: I submit it is very material, your Honor. I want to show your Honor that throughout the entire time——

Mr. Clark: Just a minute, this is the Independent Lamp Company, who is not a party to this case, and I cannot see how any work that company did, following the Pacz invention can have any effect on the validity of the patent.

The Court: He wants to show continuation of the same thing right up to and including and past the time of the Pacz patent, and I will take it for what it is worth.

Mr. Darby: Not only that, your Honor, but I expect to show by an additional witness that the practice—that the Independent Lamp & Wire Company, while this witness was there, did not depart from what it had used continuously prior to the date of the patent.

The Witness: That was in 1912, that was before the Pacz patent, even before the application.

Mr. Clark: What I objected to was this Independent matter which you said you worked on about 1920.

The Witness: I said from 1912 on, not 1920, that is when [fol. 176] I was transferred over to the General Electric in Harrison.

The Court: You did say you did not take microphotographs until the latter part of your employment.

The Witness: No, I had photographs taken in 1912.

The Court: Mr. Darby asked you if you had microphotographs, and you said not at first but at the latter part of your employment.

The Witness: That is at the Independent.

The Court: That is what we are talking about. Do you want that answer to stand, that at the Independent you took microphotographs at the latter part of your employment?

The Witness: Yes.

The Court: What year did you start?

The Witness: About 1918.

The Court: From 1918 on?

The Witness: Yes.

The filament that I took microphotographs of in 1918, made the same way it had been made since I entered their employ in 1912 with doped wire. I have no microphotographs showing the crystalline structure of the filament of the Independent Lamp & Wire Company used in their commercial lamps.

These are some more of the Westinghouse pictures, in 1912. Those are some more of the crystalline structures in 1912. They show the same irregular crystalline structure that we were working for and wanted to get so as to prevent offsetting and prevent drooping and sagging of the filament. [fol. 177] They are larger magnification than Exhibit O-1. This one is similar, but this one is very much larger.

Mr. Darby: I will offer the additional microphotographs of the Westinghouse, 1912, the first as Defendants' Exhibit O-2, the one which the witness describes as having the larger magnification; and, second, as Exhibit O-3, the one which had the same.

The Court: Mr. Witness, up to 1920, when you left the Independent, did you see any wire produced that was sagless and did not offset?

The Witness: Oh, yes, lots of it. Made thousands and thousands of lamps, regular production from 1915 on, producing it.

The Court: That was what you were studying, was the sagless, non-offsetting wire?

The Witness: That is what we wanted to make. Of course, we wanted to get the best quality, that would stand up the longest without sagging. That is what we were working for.

The Court: In order to complete that type of study you needed many pictures?

The Witness: Yes.

The Court: Have you any large pictures or do you know of any in existence showing non-sagless and non-offsetting wires at that time, up to 1920, when you left the Independent?

The Witness: Why, these pictures of the Westinghouse——

[fol. 178] The Court: No, you do not answer my question.

The Witness: Up to——

The Court: Up to 1920, when you left the Independent had you taken any large pictures showing non-offsetting and non-sagging?

The Witness: No, but they have lamps to be presented to the Court.

The Court: You just take care of yourself. I am asking you. Did you take any pictures?

The Witness: No.

The Court: I wanted to see if there were any in existence.

Mr. Darby: When your Honor says large pictures, you mean microphotographs?

The Court: Yes, enlarged microphotographic pictures of wire that would show the sagging at one time and the non-sagging as you progressed.

Mr. Darby: I don't know. I will ask the witness.

The Court: That might give you a thought, Mr. Darby, that might get you in trouble. Do not let it get you in trouble. I am trying to get a little light.

Q. 67. Was it the practice at any of the plants at which you were employed to take enlarged microphotographs of that kind, namely, of the picture of the filament itself suspended between its normal supports?

A. Why, not that I know of. It was not the practice in the plants, so far as I was aware, of taking large microphoto-[fol. 179] graphs similar to the one shown in the two middle photographs of Plaintiff's Exhibit 16. When I went with the General Electric Company in 1921 for the purpose of making the microphotographic study of the filaments of the commercial lamps, I was furnished with microphotographs of the Pacz filament, shown what the Pacz filament was, and hoped that I would be able to produce some pictures as good as that, showing up what the Harrison lamp was. I have retained

possession of those microphotographs. These are four pictures from Cleveland submitted by Mr. Dorticos to me as samples of what the C wire was in Cleveland, and I was to try to make my pictures equally good; I think they were perhaps even a little better than that. The notation on the back of those microphotographs is the original notation that was handed to me. These are pictures that were sent on evidently from Cleveland of the 218 wire.

The Court: With notations on them and the notations were on them when he got the pictures.

The notations were already on there when Mr. Dorticos gave them to me.

Mr. Darby: I offer the four photographs produced by the witness in evidence, with the notations on the back.

(Marked Defendants' Exhibits P, P-1, P-2 and P-3, in evidence.)

Comparing the microphotographs, Exhibits P to P-3, inclusive, with the microphotographs of the Westinghouse [fol. 180] 1912 filament, with respect to grain structure and arrangement, there is a very similar grain structure, very coarse and very irregular, and would have a similar physical quality when the wire was used and drawn down into a lamp, preventing offsetting and preventing drooping and sagging, by the coarse crystalline structure. That is what we wanted to get, what we were working for. Insofar as the coarseness of the crystals and the relative arrangement of the crystals is concerned, controls the subject of sagging, the filament having the crystalline structure illustrated in Defendants' Exhibits P to P-3, inclusive, was very similar to those of Defendants' Exhibits O and O-1, inclusive and produce similar results.

I made a microphotograph of the Pacz filament after it had been used, burned, and retained it in my possession. This is a microphotograph that I took of the Pacz filament wire with the General Electric Company after it had been burned. I do not recall what the length of life, length of burning was, but it burned long enough to show up as a crystalline structure. That was taken in Harrison in 1922. Comparing the crystalline structure, insofar as its irregular arrangement is concerned, as well as its grain, of this microphotograph with the four Westinghouse microphotographs,

Defendants' Exhibits P to P-3, inclusive, it shows a very similar result of irregular coarse crystalline structure, almost like as if they were similar samples, the same sample.

Mr. Darby: I offer this last microphotograph produced [fol. 181] by the witness in evidence showing Pacz filament after it had been burned.

(Marked Defendants' Exhibit Q in evidence.)

I was given instructions as to what was considered to be a permissible sag in a filament. This is a letter that was given to me at the time in 1922. It is a letter from Mr. Needham sent to Mr. Dorticos, and tells how the British Thomson Houston Company in England used to mount the specimen, shows the number of grains allowed and permissible sag of one-eighth of an inch, and the impurities that were in the wire from one-half to one per cent. It shows the impurities at that time were anywhere from one-half to one per cent., and it also shows that each batch was tried out and mounted, made up into 100-watt type lamps. And these were tested for non-sag, and if it was all right, it was used for C wire, and if it was not it was used for B lamps. That was given to me with the statement that it was the British practice in England. We were doing similar things and similar process at Harrison.

Mr. Clark: I object to that, it does not make any difference about what they were doing in England at the Thomson Houston Company's plant.

Mr. Darby: We are not interested in their practice, unless it was given to the witness by a member of the General Electric organization with instructions that that was to form his guide of the practice in the United States.

[fol. 182] The Court: Yes. He said that we did that, too. The only evidence that you can produce on that is the letter itself. Let him produce the letter, but let me take an interpretation from that letter. Do not let this witness interpret the letter for me.

Mr. Darby: I offer the letter in evidence.

Mr. Clark: I object to the letter as being wholly immaterial to anything in issue in this case. It is merely a memorandum from one person in the General Electric organization to other persons, neither of which is this witness, stating what the practice of the English Company was.

Mr. Dorticos gave this piece of paper to me. It showed especially how they aged the specimen, mounted the specimen and so forth, for the metalography picture taking. It was suggested that might be worth trying. It was given to me to try out to see if it was satisfactory. Mr. Dorticos was the engineer who went to England. That is a copy of the original letter.

Mr. Darby: I offer it in evidence.

(Marked Defendants' Exhibit R in evidence.)

This is a letter of 1916 which was sent to me by Mr. Laise, suggesting that I use silica, potassium, lime or chloria, or any other beneficial additional agents. I acted on this letter. I made up some batches.

Mr. Darby: I offer this letter in evidence.

[fol. 183] That is the original letter I received; in the same condition as when I received it, except for the pencil notations on it.

Mr. Darby: I offer the letter in evidence.

(Received and marked Defendants' Exhibit S.)

Microphotographs of wire that were made at the Independent Lamp and Wire Company while I was there were made under my direction by Mr. Marino. I have not retained in my possession any of those microphotographs. The microphotographs of the Independent Lamp and Wire Company filaments compared in grain size structure and arrangement with that of the Westinghouse filaments employed up to 1912 showed that we were getting a coarse crystalline structure and in that we were producing regular lamps for production and selling them by the thousands, it showed that we had certainly a non-sag wire that was satisfactorily made by doping the Tungsten. The crystalline structure compared with the Westinghouse, was very coarse structure; irregular crystals.

Comparing the crystalline structure and arrangement as to grain size and irregularity of Defendants' Exhibits O to O-3, inclusive, with the similar characteristics of the wire which is shown in the photograph, Defendants' Exhibit J for identification: These are—it has a larger magnification, but it shows that the same irregular crystalline structure which was very essential for non-sag, non-drooping

filament. The grain size, as I say in this case, is of greater [fol. 184] magnification. This one here, especially this one here, referring to Defendants' Exhibit O-2. And these, of course, are very much larger than that because this is an infinitesimal spot that is magnified. "These" has reference to Defendants' Exhibits O and O-1. It is my opinion that the grain size in Defendants' Exhibits O and O-1 as compared to Defendants' Exhibit J for identification is not necessarily larger, but it shows it is an irregular, large, coarse, crystalline structure, in all cases. Similarly comparing with the Defendants' Exhibit J for identification and Defendants' Exhibit Q: This is the one taken in Harrison, and, of course, that has a similar magnification of the coil, one coil, or part of a coil of a filament, etched, and shows the coarse irregular crystalline structure. It is the same coarse irregular crystalline structure shown in J for identification.

Defendants' Exhibits P-2, P-3, as compared with Defendants' Exhibit J for identification, shows still the same irregular, coarse crystalline structure of Pacz metal made in Cleveland. It is the same as to its coarseness and structure arrangement as that shown in Defendants' J for identification.

Q. 113. From the viewpoint of the technician in microphotography, I hand you a sheet on which has been attached a number of microphotographs, and which has been marked for identification Defendants' Exhibit K. Will you please mark in blue pencil by reference letters starting with reference letter "C," the crystalline structure which is comparable in size of grain and irregularity of the contour thereof, comparable to Defendants' Exhibits O to O-3, [fol. 185] inclusive?

A. Why, all of the Battersea samples here show that same coarse crystalline structure. This one here, of course, is one particularly elongated crystal. These two here are probably the better of the two.

The Court: Indicating by blue checks on one marked No. 6080, the other one, 13,280, the other 5510.

Mr. Clark: And saying, "This one here," he pointed——

The Court: To 15,280. He indicated this large one.

Mr. Clark: These two here, refer to 6080 and 5510. The elongated one referring to 13,280.

The middle row of photographs, this is lamp as shipped, meaning before it had been burned, and the crystalline structure is not quite so plain. It begins to show up, but it does not show up quite as plainly as with burning.

Taking the first one from the left, it is comparable in grain size and irregularity of contour with the photographs, Defendants' Exhibits O to O-3.

The Court: The first one is, the third one is.

The middle one shows a specially large crystal.

The Court: The second has a specially large crystal. How about the fourth one?

The Witness: That is thoriated, that is a very fine structure.

[fol. 186] Comparing the microphotographs, Defendants' Exhibits P to P-3, inclusive, with the Pacz filament that I made before, these Pacz pictures show the same irregular, crystalline structure, similar to the Battersea samples, and this one here, Exhibit Q, also shows that same identical structure of irregularity.

Q. 120. Now, which of the photographs, in your opinion, show substantially the same thing, that is, which of the photographs of Defendants' Exhibit K for identification, show substantially the same structure as to grain size and irregularity of contour as is shown in Defendants' Exhibits P to P-3, inclusive, and Exhibit Q?

A. This lot here, lot N971, and this lot here, lot N991, show practically an identical structure. This one here, the 989, shows a particularly large crystal, which was somewhat similar to this large crystal here. These show, this one here, shows a specially large crystal, in comparison with the other irregular crystals. Referring to Exhibit Q at particular spots around, larger crystals develop.

Q. 122. And has there been developed a large crystal in lot No. 989?

A. Yes, that is a larger crystal, it shows specially elongated.

Mr. Darby: I ask to have this sheet of photographs marked for identification.

(Marked Defendants' Exhibit T for identification.)

Q. 123. From the viewpoint of the technician in microphotography, Mr. Cowles, will you state whether or not

the microphotographs, the lower six microphotographs pasted on Defendants' Exhibit T for identification, are in so far as grain structure and irregularity of contour, the [fol. 187] same as or different from the filament structure depicted by these photographs, Plaintiff's Exhibits P to P-3, inclusive, and Exhibit Q?

A. It is the same irregular crystalline structure shown in these pictures, very similar, and the grain size is quite irregular.

Q. 125. As to grain size, would you say they were the same or substantially the same?

A. Substantially the same.

Mr. Darby: I ask to have this sheet marked for identification.

(Marked Defendants' Exhibit U for identification.)

Q. 126. I hand you a sheet which has been marked Defendants' Exhibit U for identification on which have been pasted some microphotographs, and from the viewpoint of the technician in microphotography, will you state whether or not, in so far as grain size and irregular contour are concerned, the four middle photographs are the same as or different from similar characteristics in Defendants' Exhibits P to P-3, inclusive, and Defendants' Exhibit Q?

A. These samples have similar characteristics that the Pacz metal and Harrison sample have. That is, both as to grain size and contour.

Mr. Darby: I ask to have this sheet marked for identification.

(Marked Defendants' Exhibit V for identification.)

Q. 128. I show you another sheet which has been marked Defendants' Exhibit V for identification and call your at- [fol. 188] tention to the microphotographs of crystal structure showing grain size and contour, and I ask you to compare them with the structure as to grain size and contour of the filament of which microphotographs, Defendants' Exhibits O to O-3, inclusive, of the 1912 Westinghouse filament——

A. They both show a very irregular crystalline structure, large and coarse. I would say the grain size and irregularity of contour were quite similar.

Q. 130. Now, in the filaments that you have examined at any time were the crystals ever exactly the same size or did they vary in size, some large and some small?

A. They always varied, some large and some small, very irregular.

Q. 131. Now, is that true of all the wire that you have been familiar with, that is, the Westinghouse wire, the Pacz wire and the doped thorium wire?

A. Why, the doped thoria wire usually ran in finer crystalline structure than the other doped wire. It is true of any wire that throughout its length the size and shape of the crystals will vary.

Mr. Darby: You may inquire.

Cross-examination.

By Mr. Clark:

X Q. 133. Can you give us, as accurately as you can, the magnification of each of these micrographs that you have introduced, and also tell me the condition of the metal, whether it is filament that has been burned, or whether it is ingot, or what it is. Now, Exhibit N, for example, can you tell me what the filament size is and what the magnification is?

[fol. 189] A. No, I don't recall what the filament size is, it is the common size that we were using at that time in the Westinghouse Company. I have here just a picture of it.

X Q. 134. You don't know what magnification it is?

A. I cannot just exactly say, it is about 100 times or more.

X Q. 135. 100 times or more. Is that your testimony?

A. Yes.

X Q. 136. And do you know in what condition the filament was, whether it was flash aged or burned?

A. It was burned filament to show the crystalline structure, that is what it is supposed to show.

X Q. 137. And how long had it been burned, do you know?

A. No.

X Q. 138. Now, with regard to Exhibit O-1, I notice on the back the notation 100 mil. and then "trans." I take it, that means a filament of 100 mils. in diameter and this was a transverse section?

A. That is right.

X Q. 139. And can you tell me what magnification that was?

A. I don't know just what it was.

X Q. 140. Do you know what the condition of the wire was, whether it had been burned or not?

A. It was the 100 mil. wire.

X Q. 141. What you have said with regard to O-1 applies equally to O-2 and O-3 and O, also?

A. Yes, they were similar magnifications, they were all taken with the same magnification.

X Q. 142. And do you know what magnification Q is?

A. No, I just don't recall.

Mr. Clark: That is all.

(Witness excused.)

[fol. 190] Mr. Darby: May I recall Mr. Kober, for one question, your Honor?

The Court: Yes.

Paul A. Kober, recalled, further testified as follows:

Direct examination.

By Mr. Darby:

Q. 138. Dr. Kober, while you were with the General Electric Company at the Edison Lamp Works at Harrison, did the research laboratories issue a book showing pictures of its personnel and commenting on the work it was doing?

A. Yes.

Q. 139. And is the book that I show you now the book that you refer to?

A. It is, yes.

Q. 140. Do you recall when this book was published?

A. I cannot recall definitely the year, but as far as I estimate it, it was about 1925.

Q. 141. And in the center of the book I find some photographs, and in the center photograph—is that a photograph of the research personnel at that time?

A. Yes, that is.

Q. 142. And is your picture included among them?

A. It is.

Mr. Darby: I offer this book in evidence.

(Marked Defendants' Exhibit W in evidence.)

The Court: Mr. Kober, will you look at that lamp, marked C wire, the one that is standing up straight? There are two [fol. 191] lamps, are there, shown at the bottom of the picture?

The Witness: That is right.

The Court: Take the one at the bottom to the left. Do you see that wire sags, doesn't it?

The Witness: It does.

The Court: It is marked C wire, which is comparable to the 218 wire, is that right?

The Witness: That is right.

The Court: You have a CX wire figure in the lamp to the right, haven't you?

The Witness: That is right.

The Court: Does that C wire—does that picture of the C wire showing the—was that taken of a lamp that had been in use a long time?

The Witness: Those are not regular standard lamps for the trade. Those were lamps made up especially to show the relative sag.

The Court: Is that lamp to the left, showing the sag, one that was in use a long time?

The Witness: No, it was made up especially for this test and for this test only, and it has been for that purpose only. It had not been used before.

The Court: Is that a picture of a lamp with a wire that was in use a long time?

Mr. Darby: How long had the lamp been burned?

[fol. 192] The Witness: It had not been burned at all.

The Court: How did you get the sag there? Did you just put it there yourself, or did the lamp put the sag there by use?

The Witness: I mounted this C wire filament similarly as shown in the CX wire lamp, that is, they were both topped and scraped.

The Court: I do not think you get my point. Is that just simply a lamp that has never been burned, that has never been used, pictured by you to show what might happen to a lamp, or did it actually happen?

The Witness: It actually happened.

The Court: Then this lamp on the left, marked C wire did burn, didn't it?

The Witness: It did burn, yes.

The Court: How long a time did it burn, long or short?

The Witness: Oh, about ten minutes.

The Court: And that is what happened after it burned?

The Witness: That is what happened, that is right.

The Court: And you took a picture of it. And then after it was treated with your material, it became a CX wire, and after burning ten minutes, I assume that it looked like the figure on the right?

The Witness: That is right.

The Court: And you turned this all in to the General Electric?

[fol. 193] The Witness: Yes.

The Court: That is a better wire than the Pacz wire, isn't it?

The Witness: I should say it is.

The Court: Why didn't you use it?

The Witness: The reason they haven't used it up to the present time—up to the time I left the General Electric was that while this was an absolutely non-sag wire and had ideal non-sagging qualities, unfortunately the wire did not give the same life as the Pacz wire. It averaged about 86 per cent. of the life.

The Court: The light was not as clear as the Pacz wire?

The Witness: The life. In other words, let us say, for example, the Pacz wire lamp on the 75-watt would burn, say, a thousand hours at the rated efficiency.

The Court: And this would burn but——

The Witness: 860 hours. That was true for all the tests I made. And that was one difficulty I did not overcome at the time I left the General Electric Company, that is, to get the life.

The Court: You have explained it. I kept wondering if they had a good material, why a large company like that, or any company, did not use it. Now you have made the explanation.

Mr. Darby: Your Honor, rather than have your Honor think for a minute that we have attempted to conceal that fact, that is all covered in the reports, that is, the deficiency of the life.

[fol. 194] The Court: That is all right. These pictures speak louder to me than the reports for the moment.

Mr. Darby: I thought it served no useful purpose to take the witness over what the report itself says.

The Court: You see, when something troubles me, I like to have it cleared up.

Mr. Darby: Absolutely.

Mr. Clark: May I say just a word about this?

Mr. Darby: Just before you do that, may I clear up one point while he is still on the stand?

By Mr. Darby:

Q. 143. When you tested the two lamps for comparison purposes, I am referring to the two lamps at the bottom of the page, were they connected in series, the same circuit?

A. Yes, they were.

The Court: That was definitely clear, I got that. He ran at ten minutes, starting with 60 volts and then increased it——

The Witness: Up to normal.

The Court: Up to normal voltage.

Q. 144. So that both lamps got exactly the same time of treatment?

A. Yes.

Mr. Clark: I want to remind your Honor, with respect to that sag which your Honor noted in the lower horizontal lamp marked C wire, 20 mil. mandril, that sag occurred dur-
[fol. 195] ing the initial or flash-ageing.

The Court: Yes.

Mr. Clark: And that that mandril was what we call a 20 mil. mandril, and there was a long span there which would accentuate the sag during that interval.

The Court: Yes, he said it was run for ten minutes, and the wire would set then, and the sag would be less.

Mr. Clark: It was brought out in the report, only I want to say that this isn't any time sag following the initial set during the heating point.

Mr. Darby: Mr. Clark's explanation necessitates my asking the witness another question.

The Court: All right.

Q. 145. Did the filament sag additionally after your initial lighting?

A. After the 60-volt application.

Q. 146. It sagged additionally?

A. Yes.

The Court: Which one?

Mr. Clark: Which one?

The Witness: The C one.

The Court: The C one sagged more than that?

The Witness: When I applied 60 volts it sagged.

The Court: Take this figure marked C wire, 20 mil. mandril, that showed a sag after burning the lamp about ten minutes, is that right?

[fol. 196] The Witness: Yes, sir.

The Court: Did it get greater or lesser as time went on?

The Witness: It remained almost, it didn't change much during the 60-volt application, but when I brought it up to normal voltage, there was an additional sag of a small amount.

The Court: More than what is shown in this picture here?

The Witness: No, that is the final.

The Court: That is the final?

The Witness: Yes.

The Court: As time went on, as you used that lamp, is it my understanding that that would get greater or less, that sag?

The Witness: No, not very much. After about an hour, as I recall, that sag finally stopped. And as shown in that picture, that is about the limit after about an hour's period.

The Court: Wouldn't it get lesser as time went on, or would it stay the same?

The Witness: It stayed the same.

By Mr. Darby:

Q. 147. If I may clear that point up as I understand it, the instant that you turned the light on a certain amount of sag developed at once?

A. Yes, immediately the first time that lamp was lit it immediately sagged very decidedly; while the CX did not sag at all.

Q. 148. All right, just a minute. Then you continued [fol. 197] passing a current through it for a total time of about ten minutes, as I understand it?

A. Yes.

Q. 149. And an additional sag developed between the set that it initially took and the condition as it is shown to reach the condition as shown in the photograph, is that right?

A. Yes, but the additional sag was not nearly as much as the initial.

Q. 150. The initial sag was the greater in amount, but an additional sag developed in that ten minutes?

A. Yes.

EMANUEL SPIELHOLZ, called as a witness in behalf of the defendant, being first duly sworn, testified as follows:

Direct examination.

By Mr. Darby:

I reside at 589 Eastern Parkway, Brooklyn. In 1920, I received my bachelor's degree in chemical engineering, in 1923, my Ph. D. degree, both from the University of Pennsylvania; from 1927 on, doing consulting work; starting in Tungsten about 1932, as a consultant.

Q. 4. Did you have occasion to manufacture Tungsten filaments according to the Battersea process?

A. I did, about 1932, and November of last year.

Q. 6. What was the occasion of your investigating the production of filament under those circumstances?

A. Solely to acquaint myself with Tungsten from the [fol. 198] very beginning, the problem which I had to take care of necessitated the knowledge of Tungsten. That knowledge of the Battersea Crucible came from the Coolidge patent, a copy of which I obtained in 1932 or thereabouts, and made a study of.

Q. 11. Where did you obtain the Battersea Crucible?

A. I had to send or had sent for it over to England to get some; I couldn't get any in New York City.

Q. 12. Were you successful?

A. Yes, I was.

Q. 13. What did you do with respect to the manufacture of filament after you obtained the Battersea Crucible?

A. I proceeded to manufacture Tungsten, according to the patent, following it explicitly. That is the Coolidge patent.

Q. 15. What did you do with the filament? Did you draw the filament out?

A. Yes, the Tungsten powder was then processed according to the patent and drawn down, made into lamps, and I photographed some of those crystals which I had found in the burnt filament.

Q. 16. Was that done in contemplation of this suit?

A. No, that was done for my own information.

Q. 17. Did you have microphotographs made of the Tungsten filament?

A. I made those myself.

Q. 18. And those filaments were all produced in the Battersea Crucible?

A. Yes, they were.

Q. 19. I hand you Defendants' Exhibit J for identification, and ask you if you can identify that microphotograph?

A. That is one of the photographs which I made.

Q. 20. When you refer to the Coolidge patent, do you refer to Coolidge Patent No. 1,082,933, which is marked in evidence as Plaintiff's Exhibit 2 in this case?

A. Yes, this is the one.

[fol. 199] Q. 21. Is that microphotograph which is marked Defendants' Exhibit J for Identification an extreme illustration, or is it typical of the grain structure of the Battersea Coolidge filament that you produced?

A. This is rather typical. Of course, these crystals stand out better than some did, but on the whole it was typical of the crystals in the wire. That is, as to shape and contour and size. I made that microphotograph myself.

Mr. Darby: I offer the microphotograph in evidence which has been heretofore marked Defendants' Exhibit J for Identification.

(Defendants' Exhibit J for Identification marked in evidence.)

Cross-examination.

By Mr. Clark:

X Q. 24. Will you tell me what magnification this Exhibit J is?

A. Yes, that is a little bit over 200 diameters.

X Q. 25. A little over 200?

A. That is right.

X Q. 26. What was the wire or the filament of which that was a photograph?

A. That was a hundred watt filament burned for about 500 hours.

X Q. 27. After burning for about 500 hours?

A. That is right.

Mr. Clark: That is all.

(Witness excused.)

Mr. Darby: I will offer in evidence a copy of the file wrapper of the patent in suit.

(Marked X in evidence.)

[fol. 200] CLEMENTS A. LAISE, called as a witness on behalf of the defendants, being duly sworn, testified as follows:

Direct examination.

By Mr. Darby:

The Court: Is this your expert?

Mr. Darby: He is a fact witness as well as the expert.

Age, 49; residence, Tenafly, New Jersey; chemical engineer. I graduated from the University of Pennsylvania in 1908, with the degree of Bachelor of Science in chemical engineering. Shortly after graduation I took a position with the Westinghouse Lamp Company of Bloomfield, New Jersey. Three years later I received my degree of chemical engineer from the same institution. From 1908 until the middle of 1913 I was with the Westinghouse Lamp Company.

During this period I had charge of the chemical supervision and technical supervision of filament manufacture and of certain lamp manufacturing operations.

The middle of 1913 I left the Westinghouse Lamp Company to study at the University of Berlin, and simultaneously did some consulting work for the Watt Incandescent Lamp Company, Vienna, Austria; and later in the year assumed a position with them as technical supervisor of their filament manufacture, and especially introduced nitrogen lamps manufacture, and the manufacture of coiled filament lamps.

That was in Vienna. Toward the latter part of 1914, owing to the war, I returned to the States and immediately [fol. 201] accepted a position with the Independent Lamp & Wire Company, taking charge of their filament manufacture, and shortly thereafter I took charge of their metallurgical department, and especially the manufacture of all kinds of tungsten products. I also started the manufacture of nitrogen-filled lamps for this company.

I stayed with this company until about 1920, when I organized my own company, the Independent Contact Manufacturing Company, and simultaneously did consulting engineering work. This consulting work resulted in my erecting a plant for the Save Electric Company about 1923 in Toledo, Ohio, the plant being called the Electron Relay Company, which manufactured the tungsten filament and other products, and did development work for the Save Electric Company.

Some time during 1924 the Save Company and the Electron Relay Company were purchased by the General Electric Company, and I returned East and assumed more active work in my own Contact factory as well as organizing a new company called the Callite Products Company which manufactured tungsten filament and molybdenum products as well as tungsten products.

During 1929 this company was merged with the Eisler Electric Company, and I am at present president of the Eisler Electric Corporation and doing consulting work. The Callite Company still operates as the Callite Products division, being a division of the Eisler Electric Corporation. The Independent Lamp Company was also bought up by the General Electric Company some time in the early 1920's, I think.

[fol. 202] Q. 7. Was it a substantial manufacturer of incandescent lamps?

A. It was a very substantial company.

Q. 8. Can you give me an approximate idea of the annual production of lamps of that company?

A. We were producing more than 35,000 lamps a day.

Q. 9. Was the Save Electric Company a substantial manufacturer of lamps?

A. It was also a very substantial company that manufactured up to sixty or seventy-five thousand lamps a day when I left the employ of that company.

Q. 10. Is it your company that supplies the defendant Wabash Appliance Corporation with filament for its lamps?

A. We in part supply them with some filament.

Q. 11. There are two questions I will ask you: First, do you produce your filament in accordance with a process which you regard to be secret?

A. We produce it according to our own process which in part is secret.

Q. 12. Do you in producing the filament that you sell to the Wabash Appliance Company add an alkaline silicate?

A. We add no alkaline silicate to the filament supplied to Wabash.

Q. 13. Speaking chemically, is boric acid a compound of boron?

A. Yes, sir.

Q. 14. Do you add to the filament that you supply the defendant Wabash Appliance Company a boron compound?

A. We do.

Q. 15. Starting with your work with the Westinghouse Lamp Company, what was the type and nature of filaments that you there became familiar with as actually used in commercial practice?

A. When I first started with the Westinghouse, we were [fol. 203] manufacturing the squirted filament of tungsten. That is a filament that is squirted through a die and sintered. When I say sintered, I mean a current is passed through the filament, and it was shaped into a hairpin form and the lamp for all intents and purposes looked very similar to the present straight filament lamp, except it was not a continuous filament when I first started. Later on, at the Westinghouse, we manufactured a continuous squirted filament, which looked almost identically the same as the present tungsten wire type of filament.

Q. 18. Was it a practice of drawing the squirted filament at any time?

A. Squirted filament was not drawn.

Q. 19. It was not drawn, but it was squirted in a continuous length?

A. That is correct, and looked just like, very much like tungsten wire,

Q. 20. Were you ever familiar with the practice of doping filament?

A. The practice of doping had started when I resumed work with the Westinghouse Lamp Company. At that time Dr. Lederer of Vienna was connected with our company, and he had made some very elaborate tests on doping, and he came over to the States in 1909 and showed us how to dope filament. At that time we doped filament with such dope as lime, as thoria, as silica, as potassium silicate and aluminum, et cetera.

Q. 21. When you say doping a filament, what do you mean?

A. Doping a filament was to add beneficial additions to the tungsten so that after a filamentary body was made out of that tungsten, the filament would not offset or sag. We furthermore continued these experiments of doping, as we went on, and by 1910 the drawn wire filament began to [fol. 204] make its appearance and, naturally it followed that we would try the same dope in the oxide in which we made filament for the drawn wire lamps as for the squirted filament lamps. And we actually did so. That practice adopted in producing a filament which was used in the commercial output of the Westinghouse Lamp Company while I was there.

Q. 24. And with specific reference to the dope, what was it, sodium silicate or potassium silicate, which was it you used?

A. Well, at that time, we followed the teachings of Coolidge who stipulates that you either add the dope to the oxide, or you obtain the dope by adding a Battersea Crucible and distilling a part of the constituents of the Battersea Crucible into the tungsten. Besides that, since we couldn't control the per cent of dope by the Battersea process, we gradually developed a process where the actual stipulated amount was added to the oxide and the oxide was then fired in a silica tube.

Q. 25. And when was that, when did you adopt that?

A. That was early in 1913. And amongst the dopes that we added to the tungsten for wire purposes were lime and silicates.

Q. 26. Alkaline silicates?

A. Alkaline silicates.

Mr. Clark: I ask that when examining these fact witnesses about so-called prior uses, you do not put words into their mouths; let the witnesses testify.

Mr. Darby: All right.

Q. 27. In what forms were silicates actually used?

A. We actually had one solution which was a potassium silicate solution, another solution which was a sodium [fol. 205] silicate solution, and we had a lime solution, and we had a thorium nitrate solution.

Q. 28. And were filaments produced at that time, in 1913, actually used in commercial lamps?

A. They certainly were in large numbers.

Q. 29. By the Westinghouse Lamp Company?

A. By the Westinghouse Lamp Company.

Q. 30. Chemically speaking, is sodium silicate an alkaline silicate?

A. Sodium silicate is an alkaline silicate.

Q. 31. Is potassium silicate an alkaline silicate?

A. Yes, sir.

Q. 32. Have you lamps in your possession and which have been in your possession since prior to 1917, which were made at the Westinghouse Lamp Company while you were there, and which contained filaments made in the manner that you have described?

A. No, I have no Westinghouse lamps.

Q. 33. When did you leave the Westinghouse Company, when was that?

A. The middle of 1913.

Q. 34. As I understood your testimony, you then went with the Independent Lamp and Wire Company?

A. No, I went to Europe and worked for the Watt Incandescent Lamp Company.

Q. 35. When did you enter the employ of the Independent Lamp and Wire Company?

A. Late in 1914.

Q. 36. What was the practice in the Independent Lamp and Wire Company with respect to its manufacture of filament for its lamps?

A. At the Independent Lamp and Wire Company, when I arrived there, they were practicing substantially, they were [fol. 206] also adding a beneficial addition to the Tungsten, and they were using the Battersea Crucible method for the manufacture of Tungsten filament.

Q. 37. And after you went with them what change, if any, did you make in their process of producing filaments for lamps?

A. We continued the use of the Battersea Crucible method for about a year and a half, and simultaneously we also practiced the prior process of adding beneficial additions, especially to the oxide, and firing that oxide in a silicate tube.

Q. 38. And what beneficial addition did you add?

A. We added lime, we added potassium silicate and we added thorium nitrate. That is, we made four different grades of wire, one being made with thorium nitrate to produce a thoriated filament, another being made by the Battersea method, to produce a filament for coiled filament lamps, another being made by the addition of lime and firing in the silica tube, also to produce a coiled filament lamp.

Q. 39. I would like to refresh your recollection, Mr. Laise, as to whether or not you have any lamps of the Westinghouse Company that were made while you were with them. Have you not a 250 Watt lamp of the straight filament type?

A. As I remember, I gave you a lamp a few days ago which I had in my possession since 1917, but I do not think it is a Westinghouse Lamp, I think it is a General Electric Company lamp.

Q. 40. Will you examine the lamp and tell me which it is?

A. Yes, it is a General Electric Company lamp, but it has the same construction as the lamps illustrated in this specification.

Q. 41. This is the specification of what company?

A. Showing the type of 250 Watt lamps I made at the Westinghouse Lamp Company in 1912.

[fol. 207] Q. 42. Do you recognize and can you state from an examination of this specification that there were made to your knowledge, lamps in accordance with this specification while you were with the Westinghouse Company?

A. We made thousands of lamps according to this specification which looked practically identically like that lamp.

Mr. Darby: I offer the specification in evidence.

(Marked Defendant's Exhibit Y in evidence.)

Q. 43. Now, how long has this lamp been in existence? How long has it been in your possession?

A. That lamp has been in my possession since prior to my leaving for Europe. Oh, pardon me, not this lamp.

Q. 44. Is this it?

A. This lamp has only been in my possession for six months.

Q. 45. Where *does* the lamp that you have had since you left the Westinghouse Company? That is the one I am trying to locate. Could you locate it for me?

A. I did not submit any lamp. This is the lamp made according to this specification, but this is not a Westinghouse lamp. It is a General Electric. In other words, it represents a type of lamp made similar to the specification.

Mr. Darby: My puzzlement was that I was advised this was in his possession since the witness left the Westinghouse Company, but I am advised now it has been in the possession of another witness.

Q. 47. Have you in your possession lamps which were made by the Independent Lamp and Wire Company prior to [fol. 208] 1916 or 1917?

A. I have, yes, sir.

Q. 48. Will you produce those lamps?

A. (Witness complies.)

Q. 49. Are the lamps that you have produced the ones that were made by you under your direction while you were with the Independent Lamp and Wire Company?

A. These lamps were made at the Independent Lamp and Wire Company between 1914 and 1917.

Q. 50. Do you refer to all the lamps?

A. All of the lamps.

Q. 51. Will you take them one at a time and describe them, starting with the big one, and give me the operating data and the exact date they were made, if you know, and any other information that you can?

A. The large lamp with the large coil was a gas-filled lamp of the type that we manufactured in 1915. It was a 750 Watt lamp, and it employed a closely wound coil.

Q. 52. Do you know how long that lamp has been burned?

A. That lamp burned 100 hours.

Q. 53. Has it sagged, has the filament sagged?

A. It is a commercial non-sag filament.

Q. 54. And when, as near as you know, if you know, was that lamp built?

A. This particular lamp was built in October, 1916.

Q. 55. In what respect, if any, does it differ from the lamps that were built beginning in 1915, according to your testimony?

A. The fiilament coil was identical to it.

Q. 56. How was the filament made?

A. The filament was made by the Battersea Crucible method and the Coolidge wire method.

Q. 57. Was any dope added to it other than through the [fol. 209] crucible?

A. In 1916 we fired the filament in silicate tube and added lime to the filament.

The Court: The question is, did that one have that?

The Witness: This particular lamp?

The Court: Yes, that is what he asked you.

The Witness: This particular lamp had lime and silica and alkaline silicates added to it.

Q. 59. That is, added to it in addition to what it got from firing in a crucible?

A. The alkaline silicate was developed during the firing operation.

Q. 60. In the crucible or tube?

A. In the tube.

Mr. Darby: I offer this lamp in evidence.

(Marked Defendant's Exhibit Z in evidence.)

Q. 61. How was this lamp intended to be normally operated, in a vertical position?

A. In a vertical position.

Q. 62. Will you take the remaining lamps you have in your hand, one at a time, and give the same information?

A. These are two straight filament lamps, manufactured in 1915. They were produced——

Q. 63. That applies to all four of them, or just two?

A. Just these two. They were manufactured with thoriated Coolidge filament.

Q. 64. Thoriated filament?

A. Yes, sir.

Q. 65. Can you state how long these lamps have been [fol. 210] burned, if at all?

A. This lamp—they have both been burned, but I do not know the exact number of hours.

Q. 66. Have the filaments sagged in those lamps?

A. No, the filament has not sagged in these lamps.

Q. 67. What is the normal voltage for those lamps?

A. They are 110 to 120 volt lamps.

Mr. Darby: I offer these two lamps in evidence.

(Marked Defendant's Exhibits AA and BB in evidence.)

Q. 68. Will you proceed with the next lamp?

A. I have here another lamp which is the type of nitrogen-filled filament lamp produced in 1916 at the Independent Lamp & Wire Company, and is a lamp produced in 1916, the latter part, at the Independent Lamp & Wire Company.

Q. 69. And has that lamp been in your possession since that time?

A. That lamp has been in my possession since then.

Q. 70. How is the filament made?

A. This filament is also produced by the Battersea process.

Q. 71. How long has it been burned, if at all?

A. That lamp has burned at least 500 hours.

Q. 72. Has the filament sagged?

A. It has not.

Mr. Darby: I offer the lamp in evidence.

(Marked Defendants' Exhibit CC in evidence.)

Q. 73. Now, with reference to the Exhibit Z, which is the large lamp, have you any contemporaneous document which, in addition to your recollection, fixes the time at which that [fol. 211] type of lamp was manufactured?

A. I have here a specification which I have had in my possession, and one on which I prepared the specification and had it drawn by Mr. Kahle, L. C. K.

Q. 74. Was that in the form of a blueprint?

A. In the form of a blueprint which is dated 4/27, 1915.

Mr. Darby: I offer the blueprint in evidence.

(Marked Defendants' Exhibit DD, in evidence.)

Q. 75. I will ask you does that blueprint depict the structure of the lamp exhibit Z?

A. It depicts the structure of lamps made in 1915, and of the exhibit substantially.

The Court: This is a 400 or 500 watt?

The Witness: It is 500 watt, the other is 750 watt, that is why I say substantially.

Q. 76. What different wattages did you make that type of lamp in?

A. We made that type of lamp from 100 watt to 1,000 watt in the beginning, but later we made the 100 watt lamps with the circular coil.

Q. 77. When did the Independent Lamp & Wire Company start to sell coiled filament lamps to your knowledge?

A. When I assumed work, at the time I was employed by the Independent Lamp & Wire Company in 1914, they were selling some coiled filament lamps, but they increased their manufacture of coiled filament lamps substantially early in 1915.

Q. 78. Were these lamps of the type of Exhibit Z, regard- [fol. 212] less of wattage, sold in substantial quantities, or only a very few of them?

A. In very substantial quantities.

Q. 79. With respect to the filament retaining its shape in use, is Exhibit Z a typical illustration or is it an extreme illustration?

A. It is a typical illustration.

Q. 81. With respect to the subject of offseting of the filament, is the lamp Exhibit Z a typical illustration or an extreme illustration?

A. No, it is a typical illustration.

Q. 82. Has the filament in this lamp, Defendants' Exhibit Z, offset?

A. It has not offset and it has not sagged.

The Court: Can you tell that by looking at it, offsetting?

The Witness: Usually, if it offsets, it becomes very crystalline, and you can almost see that with the naked eye.

The Court: Is it possible to offset and you not see it except by taking microphotograph pictures of it?

The Witness: To really determine offsetting, one should take a microphotograph.

The Court: If you light that up could you tell whether it offset or not?

The Witness: No, we could not.

The Court: Could you tell if it sagged, if you lighted it up, or can you tell whether it sags much by just looking at it?

The Witness: You can tell almost by looking at it. Sag is all a question of degree.

The Court: Sag is a question of the way you look at it?

[fol. 213] The Witness: There is no such thing as a commercial filament lamp which is a hundred per cent. non-sag, except the Schaller process filament.

Q. 83. Which is a single crystal bulb?

A. Single crystal bulb.

The Court: In other words, all filaments sag more or less.

The Witness: Yes.

The Court: Some more than others?

The Witness: Yes, and certain lots that you prepare, one lot would give you very fine characteristics, which are almost non-sag, and other lots will sag considerably. And that is why we control every lot of filaments and eliminate those lots that have a tendency to sag more and verge on the side of non-commercial lamps—verge on the side of non-commercial lamp filaments that will produce lamps that have a tendency to produce excessive drooping. On the other hand, all filaments of this V-shape type, if they are burned in a horizontal direction, will droop and will sag, which I am also prepared to show you.

Q. 84. That includes the General Electric commercial lamps?

A. Even the so-called Pacz filament of today will do the same thing.

Q. 86. In answering my questions as to whether or not that filament will sag, have you understood my question to mean sag substantially to an objectionable extent?

A. This is considered a non-sag filament.

[fol. 214] The Court: That is a relative term, too isn't it?

Q. 87. Is there any substantial sag in the filament of the lamp?

A. There is no substantial sag in this filament.

The Court: Some time both of you gentlemen show me where the line is. I haven't gotten it yet.

Mr. Darby: I wish I could show you.

The Witness: I will try to.

The Court: "Substantial" covers a multitude of sins on both sides. It is not a mathematical problem, that is exact. It is one of those things where you can stretch your imagination either way. I suppose if I should make a lamp, I would call it the best in the world, and say it is non-sag, and if somebody else made one, he would say mine is a sagging lamp and his is not, and they both would be the same.

Mr. Darby: You will recall that in my opening statement that is one of my criticisms of the patent, and the law lays upon the patentee the necessity of laying out his boundary lines.

The Court: I am letting you men make your record for a possible appeal. I think you deserve that. That is why I am going ahead, but I will show you within an hour, I will get what I want to get out of this, and all this trial you can take an appeal later on, one or the other. I am going to be very practical about this thing. I am not going to borrow [fol. 215] any more trouble than I have to, and you are not going to get any hundred-page opinion here either. You are going to get a very short opinion, right to the point, and I am going to give the Circuit Court no room to guess at what I mean.

Q. 88. Doctor, have you made or had made for you under your direct supervision filaments made strictly in accordance with Coolidge Patent No. 1,082,933, and then had microphotographs made of the filament in the various stages, both as unburned filament after flashing and ageing, and after burning a hundred hours, and made grain count of the filament of the different batches?

A. I have.

Mr. Darby: We have endeavored to make these charts speak for themselves, and I can take care of it by asking the witness two questions.

The Court: Yes.

Q. 89. Are the microphotographs attached to Defendants' Exhibit K for Identification micrographs—microphotographs respectively of filaments taken from four different lots produced strictly in accordance with the Coolidge Patent 1,082,933, showing the condition of the filaments in unburned condition, in condition after flashing and ageing, labeled filaments from lamps as shipped, and after the filaments have been burned over a hundred hours as

well as the grain count and sag of the filament after burning a hundred hours, measured in millimeters?

A. They are, yes, sir.

[fol. 216] Q. 90. Is it correct that the grain count is given at the bottom rows of the photographs?

A. The grain count is the count of the treated slug before being made into the filament and is given at the bottom of the photograph.

Q. 91. And will you please explain the sag in millimeters of the heavy filament which I see varies from 48 in the first column, 1 to 2 in the second, 2 in the third, and 4 to 9 in the last?

A. I made four different lots of Coolidge wire, and took the sag test on the same. By measuring the droop or sag of a hairpin filament taken from these lots at 100 mil. in lot No. N971, which was the first lot, we had a sag of 48 millimeters; lot No. N989, we had a sag of 1 to 2 millimeters; lot No. N991, we had a sag of 2 millimeters; and lot N5143, a sag of 4 to 9 millimeters, showing that there is considerable variation when you produce filament by the Coolidge tube.

Nevertheless, we produced millions of meters of Coolidge filament with the Battersea process that was commercially non-sag filament, and by making these sag tests we would eliminate, or we could eliminate the high sagging lots of metal from those that had very little sag. And we usually confirmed these sag tests by making preliminary lots of lamps commercially from a particular lot of wire, and then if these lamps show an excessive sagging commercially those lots of wire were not used for filament manufacture at that time.

Q. 92. If it has been stated that a five millimeter sag was permissible, how many of the lots on this particular exhibit, that is, these lots of filament, would you be able to use for commercial non-sag lamps?

A. Two lots could be used for commercial non-sag lamps. [fol. 217] The third lot, which was a thoriated lot, which naturally was being used for commercial lamps, but only in the straight filament lamp, although I have used thoriated tungsten which has given very good results in coiled filament lamps, particularly if in conjunction with thorium there was a small percentage of alkali left in the oxide due to improper washing of the precipitated oxide.

Q. 93. Have you lamps made up from filaments in lots——
A. I have some lamps.

Mr. Darby: While you were looking for them, I will offer in evidence Defendants' Exhibit K, which has heretofore been marked only for identification.

(Defendants' Exhibit K for identification marked in evidence.)

Q. 94. You made these photographs, photomicrographs, yourself, did you?

A. These were made under my supervision. Here are three lamps, three of the lamps made from lot N989, one lot having been flashed; another having burned two and a half hours, and the third having burned 500 hours, over 500 hours.

Q. 95. Is that data contained on the labels which I see on the lamps?

A. It is.

Q. 96. Will you examine those lamps and state whether they have developed a substantial or undesirable sag?

A. Those have not got an undesirable sag; they are commercial non-sag lamps.

Mr. Darby: I offer these lamps in evidence.

(Marked Defendants' Exhibits EE, FF and GG in evidence.)

[fol. 218] Q. 97. Mr. Laise, were you able to obtain so-called Pacz or 218 wire?

A. Early this year, when some of our clients were sued, I purchased through a jobber in Newark some 218 filament, that is it was 218 improved Pacz filament.

Q. 98. As used in commercial lamps today?

A. Which is called the Pacz filament, although it is an improvement over the Pacz specification.

Q. 99. Have you the coil of filament that you were able to obtain?

A. I have here two spools of wire purchased during January or February of this year.

Q. 100. Did you use this filament for the purpose of making lamps, incandescent lamps, for the purpose of testing the lamps so made and microphotographically examining the filament at different stages of use?

A. Since we made millions of meters of filament a month of various types, we check upon the product of our competitors, and one of the purposes of this purchase was to check up and compare the quality of that wire with our present product, and I have made various tests with that wire.

Q. 101. Have you produced some lamps?

The Court: You said you knew there was a lawsuit pending, is that right?

The Witness: That is right.

The Court: Did you make tests with this 218 before this January?

The Witness: The 218, yes, we made tests with competitor's wire right along.

The Court: Did you make one last year, for instance?

The Witness: Yes, sir.

The Court: Have you got the data of that?

[fol. 219] The Witness: I have some data on, I got a G. E. lamp that we tested out the middle of last year.

The Court: With Pacz?

The Witness: So-called Pacz, improved General Electric.

The Court: Have you got that lamp here?

The Witness: Yes, I have that lamp here.

The Court: Suppose you give us that lamp in conjunction with these three lamps for the purpose of comparison.

The Witness: I would like to burn these lamps and illustrate——

The Court: You will get a chance to burn them. Suppose you get the other one, too. I want all four burned. Mark the first one at the date he made it last year, and mark this at the date he made this year, so when they are burned, if there is any difference, we will see it, and if there isn't any difference, we will see that, too.

Mr. Darby: I understand your Honor's idea.

The Court: He might have made a better one last year than this year, when he knew a lawsuit was pending. I am not unduly suspicious, but——

Mr. Darby: I understand.

The Witness: This is a lamp made by the General Electric Company and tested by us.

The Court: I want one you made last year. You say you make tests at periodic intervals.

[fol. 220] The Witness: Yes.

The Court: I think you said you made a test of this 218 Pacz last year some time.

The Witness: I did.

The Court: And you have a lamp of that?

The Witness: I haven't a lamp of that test. I have just a lamp here—

The Court: No, no.

The Witness: A G. E. lamp.

The Court: May be you don't understand me.

The Witness: I understand but I haven't——

The Court: Have you a lamp or haven't you, of that last year's test?

The Witness: We may have some lamps in the factory.

Mr. Darby: He hasn't them with him.

The Court: If you have one, bring it in the morning.

Mr. Darby: I will defer examination on this line at this time, because I would like to do all the demonstrations at one time.

The Court: Let me give you my idea. I do not care whether you test it now or not. You know, you don't have to. After you file your briefs, and after I have read the record, you may bring your two experts, and I will give you another day where you can argue to your heart's content. I think that is a good way to get at this case. You can come here and I will tell you what is in mind, after I read the briefs, and tell your opponent what is in my mind, and then [fol. 221] we can go through some of these demonstrations, which I will set forth that I want made, and then after you argue it again, within a week, you will get my decision.

Mr. Darby: All right, sir.

The Court: Because I think this idea of trying to determine this matter on briefs, after I have heard this mass of evidence might be all right but I would rather have you both here to give me a morning's argument on it. The argument will mean much to me then, because I will have digested what I want, and then what is troubling me, if there is anything, you can iron out for me.

Mr. Darby: I know that we are both very anxious to handle it any way your Honor wants it, but in view of the fact that plaintiff has made some tests, I have to meet them at this stage of the case.

The Court: Don't let me stop you from making your record.

Q. 102. As I understand it, these three lamps have all been made from the 218 wire, is that right?

A. That is right.

Q. 103. What do you propose to show with these lamps?

A. Since the plaintiff introduced some lamps burning in a horizontal position with the V-shaped coil, I propose to show that even the most recently developed type 218 filament will sag when burned in a horizontal position. For that reason, I made quite a number of lamps up and I burned, of these three, I burned one lamp, which illustrates that the filament has sagged downward.

[fol. 222] Q. 104 Let me have that particular one?

A. And two lamps that have not been burned as yet.

The Court: Wait a minute. You had better not go too fast. Better wait for Mr. Darby's questions. He knows what he is getting at legally and you do not.

Q. 106. How long was the lamp which you have burned and which shows the filament in a sagged condition, how long was that lamp burned?

A. That lamp burned five minutes, less than five minutes.

Mr. Darby: I offer that lamp in evidence.

(Marked Defendants' Exhibit HH in evidence.)

Q. 107. Are the two lamps remaining identical in structure, made at the same time?

A. They are identical in structure, made at the same time, and from the two spools of wire.

Q. 108. And have they been flashed and aged?

A. They have not been flashed.

The Court: They have not been burned at all?

The Witness: They have not been burned at all.

Mr. Darby: I offer those two lamps in evidence.

(Marked Defendants' Exhibits JJ and II in evidence.)

Q. 109. Can you operate these lamps so that they will have an initial flash so as to enable them to take the set?

[fol. 223] A. I need the set here (indicating). That was burning on 110 volt circuit. I have another one of these lamps with a straight coil instead of the V shape, which is exactly the same coil length—a 40 volt lamp.

Mr. Darby: May II be substituted for this lamp, the one that was a leaker?

Mr. Clark: A non-leaker for a leaker?

Mr. Darby: Yes.

Q. 110. Call these, when you refer to them by their exhibit numbers JJ, HH and II.

A. Now JJ has not been burned.

The Court: JJ has not been burned.

The Witness: This one, HH and II have been flashed.

The Court: Flash burned.

The Witness: And burned for less than five minutes. Now, the normal position in which these lamps are to be burned is in a vertical position, so that when I flash (turning on circuit), whereupon lamps flashed brightly and went out.

Each one of these circuits is 110 instead of 40 volts, that is why they burned out.

Mr. Darby: I would like to put on the record what happened to the filaments of the lamps HH——

The Court: Put on the record that Exhibits HH, II and JJ burned out because of some reason.

Mr. Darby: No, Exhibit II did not burn out. HH and JJ burned out, and can you state why?

[fol. 224] The Witness: Because they were 40 volt lamps and were burned on a 110 to 120 volt circuit.

Q. 110. You didn't notice that at the time?

A. I didn't notice that at the time.

Q. 111. Will you please describe the tests that you made of the lamps which you made, concerning filament of the 218 wire?

A. Mr. Darby, I have some 110 volt lamps of this construction which I could easily put in circuit.

The Court: Would they show the same thing?

The Witness: They would.

Q. 112. Were they made with 218 wire? The point is, I wanted them to be made with the 218 wire.

A. Just one minute, please. I have here another spool of 218 wire, 37.2 milligram, 110 volt lamps, kone formed with a straight coil and one formed with a V coil such as illustrated in Exhibit 19.

The Court: Were these made with 218 Pacz wire?

The Witness: These were made with this 218 Pacz filament.

The Court: Mark these in evidence.

(Marked Defendants' Exhibits KK and LL in evidence.)

Q. 113. Mr. Laise, will you please describe what you found in making that test in the past, and which test, I understand you are prepared to repeat?

A. In making lamps of this 218 filament in the V-shape [fol. 225] form such as illustrated on Plaintiff's Exhibit 19, and burning the lamp in a horizontal position, I found that the filament drooped and sagged tremendously.

Q. 114. Did you make the same test with respect to a filament made of a single crystal, such as a Schaller or Pintsch filament?

A. I made the same test with coils made in the filamentary form, and made lamps with the Schaller filament and burned them in a similar position and found that the Schaller single crystal filament had practically no drooping, was non-sag, and after burning in the horizontal position. Furthermore, I made some lamps with the straight coil and burned these and found that that Schaller filament showed no sag, and it can be taken as the basis of a true non-sag filament.

Q. 115. Did you also have some Pacz filament made up either by you or under your direction or direct supervision, which was made directly in accordance with the process contained in the patent in suit?

A. I also made several lots of filament strictly in accordance with the Pacz disclosure of Nineteen——

Q. 116. The patent in suit?

A. Of the patent in suit.

Q. 117. And did you take microphotographs of the various stages of the filament?

The Court: Just a moment. Will you come up here, electrician? Let us see if he can help us.

Mr. Darby: May I continue?

The Court: Yes.

Q. (Continuing.) Showing the filament prior to flashing and ageing, the filament after flashing and ageing, namely, [fol. 226] in the condition in which it would be labeled

shipped, and finally the filament after it had burned a hundred hours?

A. I did.

Q. 118. And did you also make grain count and measurement in millimeters of the sag of a Pacz filament made strictly in accordance with the disclosure of the patent?

A. I did.

Q. 119. And is that illustrated on the chart containing the nine microphotographs heretofore identified as Defendants' Exhibit T for Identification?

A. Yes, it is.

Mr. Darby: I offer the chart in evidence and ask it be marked Defendants' Exhibit T in evidence.

(Defendants' Exhibit T for Identification marked in evidence.)

Q. 120. And will you please briefly state what you found in millimeters, as to the extent of sag in the filament produced strictly in accordance with the patent in suit?

A. In making this standard sag test on these lots, I found that of the three lots of wire produced, only one would fall within the usual allowance of sag, and even that did not fall within the allowance of sag in that certain sections of the filament varied in the sag. The first lot showed a millimeter sag of 38; second lot a millimeter sag of 2.5 to 18, and the third lot a millimeter sag of 18 to 15. Our usual allowance of sag on good, commercial non-sag wire should not be in excess of five millimeters.

The Court: Do you mean by 38, 38 millimeters?

[fol. 227] The Witness: 38 millimeters sag according to the standard hairpin test.

Q. 121. These three sets of photographs in Defendants' Exhibit T: I note a label, "A process," "B process," and "B process." What is the difference between the A process and the two B processes?

A. In the A process the oxid precipitated from the mixture of A and B solution is directly reduced to metal and is then worked up by the Coolidge process.

Q. 122. As described by the Pacz patent in suit?

A. As described in the Pacz patent in suit. In the B process part of the metal is reduced and to a portion of that, oxid is added, in line with Pacz's disclosure in the

patent in suit, and that is known as the B process described in said patent in suit.

Q. 123. In other words, the A process is in accordance with the one process as described in the patent in suit, and the B process is the modified process as described in the patent in suit?

A. That is correct.

The Court: Now, Mr. electrician, we have here two 110 volt lamps that we want to test. Is this board good enough for that? Will it blow it out?

The Electrician: It will not blow the fuse, providing that is all that is on it.

The Court: Just these two?

Mr. Darby: The three of them.

The Witness: These are 110 volt lamps. I would like to hold these lamps in this position, since that is the normal position for the burning of lamps of this type.

[fol. 228] The Court: Held vertically?

Mr. Clark: Base up.

Q. 124. You are going to make them flash in that position?

A. Usually the flashing at a normal temperature will give it permanent, so-called permanent structure.

The Court: All right, go ahead.

Q. How long do you want the current on?

A. One minute.

The Court: You time it, Mr. Darby.

Mr. Darby: Yes, go ahead.

(Current is turned on and lights lit until Mr. Darby instructs that the current be turned off.)

The Witness: Now, these lamps have their permanent set. Now, we will burn this for five minutes in the horizontal position to see whether that filament droops.

The Court: Wait a minute. Let us see what it does now, first.

The Witness: You will find——

The Court: Suppose you describe what you see now first.

Mr. Darby: Please note in the record that these are lamps Exhibits KK and LL that are in the board.

The Court: What has Exhibit KK done since you held it vertically, describe the filament. Is there any sag in that filament, substantial sag?

The Witness: KK has developed some sag.

[fol. 229] The Court: You have been using the word "substantial." Is it substantial?

The Witness: I would still call it commercially non-sag.

The Court: How about LL, is that commercially non-sag?

The Witness: At the present time that also shows commercially non-sag structure.

The Court: All right, connect it up for five minutes, the test being made in a different position. You indicate the position.

Q. 126. Will you now test those lamps in the horizontal position such as was employed by the plaintiff in their prima facie case with respect to lamps Plaintiffs' Exhibits——

Mr. Clark: 19 and 24.

The Witness: I am now placing the——

Mr. Darby: Wait a minute.

The Court: Before you held them vertically, and they held their lamps horizontally in Exhibit 18, showing no sag. Now you are going to put these in the same position as shown in Exhibit 19, is that right?

Mr. Darby: That is right.

The Witness: And burn it for five minutes.

Q. 127. Mr. Laise, have you made a number of microphotographs comparable in character with those illustrated at the top and bottom of Plaintiff's Exhibit 32, for the ex-[fol. 230] ample of showing a comparison of structure of the coiled tungsten filaments both in unburned, and burned condition, of the thoriated tungsten filament made in accordance with Coolidge Patent No. 1,082,933, the tungsten Batterse filament made in accordance with the disclosure of the same Coolidge patent, the Pacz filament made strictly in accordance with the patent in suit, and the Schaller filament, single crystal filament made in accordance with the Schaller patent which is not in evidence but which is numbered 1,256,930—and I will say that it will be in evidence, your Honor—have you made those comparative microphotographs?

A, I have, yes, sir.

Q. 128. And are they mounted on the exhibit which has heretofore been identified as Defendants' Exhibit U for Identification?

A. Yes, they are.

Q. 129. Will you briefly describe by comparison the size and shape, the contour and relative positions of the adjacent crystals in the various filaments that you used as shown in the microphotographs?

A. The unburned Coolidge thoriated filament, the Coolidge Battersea filament and the Pacz filament made according to U. S. Patent No. 1,410,499, have a fine fibrous structure. The Schaller filament unburned shows a single crystal structure. The burned Coolidge thoriated filament, after burning two and a half hours, shows an increase in the crystal structure, but a very small one.

The Coolidge Battersea tungsten coil shows a large grain structure, almost of the single crystal type.

The Pacz filament, after burning two and a half hours, shows a coarse grained structure.

[fol. 231] And the Schaller filament after burning two and a half hours still shows a single crystal structure.

The Schaller filament therefore shows the ideal structure of a non-sag filament, whereas the thoriated Coolidge filament shows a fine grain structure, and thereby possessing the smallest amount of non-sag characteristics.

On the other hand, the Coolidge Battersea filament which absorbed a certain amount of silica and lime shows a very large grain structure, which almost approaches that of the Schaller filament.

The Pacz tungsten filament made strictly in accordance with the specification of U. S. Patent 1,410,499, does show a coarse grained filament, but it by no means approaches the single crystal structure of the Schaller filament, which really is non-sagging.

Q. 130. How does it compare with the Battersea in non-sagging characteristics?

A. In non-sagging characteristics, the Battersea filament in this particular lot was far superior to the filament prepared strictly according to the Pacz disclosure in this patent. It has therefore been the desire of filament manufacturers to gradually approach, to follow the Schaller filament structure.

Q. 131. How does that filament made in accordance with the Pacz patent compare in offsetting properties with that of the filament produced in accordance with the Battersea process?

A. The question, please?

Q. 132. You have answered my question of the comparison between the Pacz and Battersea as to sagging. Now, [fol. 232] will you answer the similar question as to offsetting?

A. The Coolidge Battersea is a non-offsetting filament, which is illustrated by the interlocking structure of the filament, and the Pacz filament, having large grains, also has non-offsetting characteristics.

Q. 133. Would you say that one is less subject to offsetting than the other, or are they about the same?

A. We might say they are about the same, although the Coolidge Battersea structure is superior from a non-offsetting point of view, also.

Mr. Darby: I offer the chart in evidence heretofore marked Exhibit U for Identification.

(Defendants' Exhibit U for Identification marked in evidence.)

Q. 134. I hand you a tube containing some filaments which have heretofore been marked Defendants' Exhibit C for Identification. Can you state what those filaments are?

A. This is an exhibit of a Schaller filament that I purchased in 1922 in Berlin.

Q. 135. And you gave—to me through my associate in this case?

A. I did, yes, sir.

Mr. Darby: I offer the tube of the Schaller filament in evidence heretofore marked Defendants' Exhibit C, for Identification.

(Defendants' Exhibit C for Identification marked in evidence.)

Q. 135. Will you examine the lamps as a result of the five minutes' burning.

[fol. 233] The Court: Take Defendants' Exhibit KK first, or take the other one first, but whichever one you take tell us which it is.

The Witness: I have burned these lamps for five minutes, and the filament shows a little droop.

The Court: Which one?

The Witness: On Exhibit LL.

The Court: Shows a little droop.

The Witness: Yes, but apparently the five minutes burning was not sufficient to effect a substantial sag characteristic in either of these.

The Court: How about Exhibit KK, no sagging there?

The Witness: Not in five minutes.

The Court: Well, your answer as to Exhibit KK and Exhibit LL after burning five minutes, there is substantially no sag in either one of them, is that right?

The Witness: I would say that in this particular test.

Mr. Darby: Tomorrow, in another part of the court room, I will subject those lamps to a one hour's run.

The Court: I will do that myself. Do you think that more than five minutes will show any difference in either one of those defendants' Exhibit KK or LL?

The Witness: It will show some difference, but just how much, I do not know.

The Court: Do you think it will show substantially sagging, as known in the trade, if I burned them for an hour?

Mr. Darby: That is more than 5 millimeters.

[fol. 234] The Witness: I have not tested this particular spool; I have tested the other spools, and I do not know whether this will or will not.

The Court: You are not sure of it one way or the other?

The Witness: I am not sure of it.

Q. 136. Is there anyway you could tell without trying, is there anyway you could predict without trying?

A. No, sir.

The Court: I will request the ba-liff to take these to the electrician of the building and tell him to burn them for five hours. Tell him not to break them, to burn them for five hours and return them to us tomorrow morning.

Mr. Darby: In a horizontal position.

The Court: Yes, in a horizontal position, he is to burn them.

The Witness: I would like to say something. The first lamps that burned out were made with two spools of wire

on which the sag test was made. On one spool we had a sag of 1.5 millimeters, and in making the sag test on the others, we had a sag of 28 millimeters.

The Court: All right. Suppose you have those marked, the one with 1.5—you should have these marked.

Mr. Darby: Yes, sir.

The Court: The one with 1.5, suppose you hand that to the bailiff.

The Witness: This spool marked 494 meters had a sag of 1.5 millimeters.

[fol. 235] Mr. Darby: I offer that spool in evidence. I offer this spool in evidence as 218 commercial wire put out by the General Electric Company.

(Marked Defendants' Exhibit MM in evidence.)

The Court: In the next spool you say you found 28 millimeters?

The Witness: In this spool marked 317 meters, that had a sag of 15 to 27 millimeters.

Mr. Darby: I offer that in evidence.

(Marked Defendants' Exhibit NN in evidence.)

The Witness: When I made the lamps that burned out from those spools, I found that the spool, by showing a sag of from 15 to 27 millimeters, drooped and sagged considerably in the horizontal position; and in view of the fact that these lamps burned out, I could not show that today.

The Court: What were these lamps KK and LL made out of, what spool?

The Witness: They were made out of a third spool, having 500 meters of 37 milligram wire. And they had a sag of 1.5 to 2. millimeters, but I never burned any of these lamps in a horizontal position before.

Mr. Darby: I offer that spool in evidence.

(Marked Defendants' Exhibit OO in evidence.)

Mr. Darby: Mr. Clark, will you concede that that is the label, the manner in which your 218——

[fol. 236] The Court: Oh, no, don't ask whether that is correct until they rebut it. Unless it is rebutted, you can safely consider that I will hold that they are their spools.

Mr. Darby: All right, sir.

Q. 138. Now, Mr. Laise, have you obtained from the defendant, the Wabash Company, their commercial lamps after they have been made with your filament?

A. Yes, sir, I have.

Q. 139. And have you made or have had made under your direct supervision microphotographs of the Wabash Lamp filament after they have been burned?

A. Yes, sir.

Q. 140. Will you state whether or not the microphotographs of the Wabash filament, Defendants' Exhibit V for identification, are those microphotographs, and do they correctly show the various conditions of the Wabash lamps that you examined?

A. These show the filament as was supplied to Wabash, and they show the structure of the filament after flashing, as it goes out in lamps and after the filament had burned 800 hours.

Mr. Darby: I offer in evidence the microphotographs which have heretofore been marked Defendants' Exhibit V for identification.

(Marked Defendants' Exhibit V in evidence.)

Q. 141. Have you had some lamps made up with the Callite filament by the Wabash Company and subjected to the same horizontal burning condition with the filament in [fol. 237] the saw-tooth form as was employed by the plaintiff?

A. I have, yes, sir.

Q. 142. Will you please pick out of the lamps those which have been flashed and burned and describe and illustrate to the court the result of thereafter burning them in a horizontal position?

A. Here are two lamps which I received from Mr. Fole.

Mr. Darby: Superintendent of the defendant company.

The Court: What do you want to prove with this, that they sag or they do not?

Mr. Darby: That they do sag, that they sag exactly the same way that the plaintiff charges the prior art to sag when subjected to exactly the same tests, that is, the horizontal test. In other words, we say that that is a most unfair test. The real test is in normal use.

A. (Continuing.) The first lamp shows the V shaped filament in normal use—V-shaped filament as illustrated in plaintiff's Exhibit 19, and the second lamp shows that same coiled V-shaped filament burned in a horizontal position for twenty minutes.

Q. 143. Here is one for thirty minutes. Let me have——

The Court: These have been tested, have they?

The Witness: I can make the same test here.

The Court: Is this the one that has not been flashed, flash burned at all?

[fol. 238] Mr. Darby: This is the one that has been burned, flashed and burned for 20 minutes.

The Court: Is that right?

The Witness: Yes.

Mr. Darby: I offer it in evidence.

(Marked Defendants' Exhibit PP in evidence.)

The Court: Look at this one. How long has that one been burned?

The Witness: That has only been flashed.

Mr. Darby: I offer it in evidence.

(Marked Defendants' Exhibit QQ in evidence.)

The Witness: And this has been flashed.

The Court: Only flashed?

The Witness: Yes.

Mr. Darby: I offer it in evidence.

(Marked Defendants' Exhibit RR in evidence.)

Q. 144. Were they substantially identical? Were they substantially identical in construction before burned?

A. Identical in construction before burning.

Mr. Darby: Now, I would like to suggest that these two lamps which have been flashed but not burned be subjected to horizontal burning.

The Court: That is Defendants' Exhibit QQ—and what is that one?

Mr. Darby: This is Exhibit RR.

The Court: Exhibits QQ and RR are going to be burned horizontally for how long a period of time?

[fol. 239] Q. 145. How long will it be necessary?

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A. The other was burned 20 minutes, but I believe this will do it in a much shorter time.

The Court: All right, two minutes?

The Witness: I would suggest burning them two minutes, and possibly another three minute period, if necessary.

The Court: All right, we will burn them five minutes now.

Mr. Clark: What are these lamps now?

Mr. Darby: They are the Wabash lamps as regularly manufactured.

The Court: They will be subjected to a five minute burning.

Q. 146. Mr. Clark, wanted to be sure of one thing, that these lamps that are being tested now, Exhibits QQ and RR are lamps which you made using filament therefor such as you furnished Wabash, is that right?.

A. That is correct.

Q. 147. That is what I thought it was and I explained to Mr. Clark, but I wanted to be sure that I was correct about it.

The Court: Mr. Darby and Mr. Clark, you will stipulate tomorrow morning that the electrician of the building has burned those lamps for five hours? They are on now. You do not want the testimony of that man, do you?

Mr. Darby: Oh, no.

The Court: I mean you could stipulate for the record that if he were called, he would testify that he burned them for five hours.

[fol. 240] Mr. Clark: Oh, yes.

The Court: If you want the witness, you can have him.

Mr. Darby: No, it is not necessary.

Q. 148. While we are waiting for the expiration of that time I handed you Defendants' Exhibit S, and ask you whether or not you recognize that, whether or not you wrote it, and whether or not you delivered it to anybody, and if so, to whom, delivered or sent it to anybody?

A. Yes, sir, this is a letter I wrote to Mr. Cowles in 1916.

Q. 149. Now, Mr. Laise, will you please compare from the viewpoint of physical structure, in so far as it affects sagging and offsetting the crystalline structure shown by the microphotograph Defendants' Exhibit Q and the crystalline structure as shown by the microphotographs of the Coolidge, Battersea and Pacz tungsten of Defendants' Exhibit Q?

A. This structure shows a coarse structure filament, identical to that of the exhibit of the Pacz tungsten filament which I prepared strictly according to the Pacz specification.

Q. 150. And what was it you referred to when you said "this" in the first instance, the Exhibit number is on the back of it, the exhibit letter?

A. It is the exhibit lettered Q.

Q. 151. In so far as those same factors are concerned, that is, the physical characteristics, in so far as they affect offsetting and sagging, will you compare the filament of Defendants' Exhibit Q with the filaments of the Coolidge Battersea crystals as illustrated on Defendants' Exhibit K?

A. The Coolidge Battersea crystals, as on Defendants' [fol. 241] Exhibit K, lot 971 and lot 9N99, are almost identical to that of Exhibit Q. The Battersea exhibit, Coolidge Battersea Exhibit 989, shows still larger crystals, and would illustrate a structure which will be still more non-sagging and non-offsetting.

Q. 152. Will you make the same comparison between Defendants' Exhibit Q and Defendants' Exhibit T?

A. Defendants' Exhibit T of the Pacz filament, prepared strictly according to the Pacz disclosure of '049, shows a structure practically the same as Exhibit Q.

Q. 153. Will you please examine the lamps that have been tested.

The Court: While you are describing them, you had better refer to these exhibit numbers.

A. The Wabash lamp, Exhibit RR, after burning five minutes, has sagged the filament, the original V-shaped filament entirely out of shape, and similarly the Wabash lamp with Callite wire, QQ, has also sagged and drooped, so that the original V-shaped coils are entirely distorted.

The Court: One is worse than the other? One has done it just a little bit and the other has done it a great deal?

The Witness: I would say that both of them have sagged quite a lot.

The Court: But I am asking you for a comparison. One sagged more than the other.

The Witness: Exhibit RR has not sagged and distorted quite as much as Exhibit QQ.

[fol. 242] Q. 154. Comparing Exhibit QQ with the photograph of Plaintiff's Exhibit 19, state whether or not the Wabash lamp has sagged more or less out of shape than the lamp on Exhibit 19, referring to the second photograph on the bottom, on the left-hand side?

A. The exhibits RR and QQ of Wabash Lamps, after burning five minutes in a horizontal position, have sagged even more than the lamp that has burned two and a half hours in Exhibit 19.

The Court: More than that one? You mean this lamp on the left here, the lamp that you show me here has burned more than the one on this——

The Witness: Sagged more, distorted more.

Mr. Darby: From its original position.

Q. 155. Will you compare Exhibits RR and QQ with the right-hand photograph?

A. The right-hand photograph, which represents undoubtedly the Pacz 218 filament, has sagged very little as compared with the Wabash lamp that has burned five minutes.

Q. 156. In other words, the Wabash lamp has sagged substantially more, in your opinion, than either of the two photographs of Plaintiff's Exhibit 19?

A. They have sagged very much more.

Brooklyn, N. Y., July 1, 1936.

(Met pursuant to adjournment at 10:15 a. m.; present as before.)

Mr. Darby: Your Honor, in keeping with the plan that you outlined, I have decided to dispense with one wit-
[fol. 243] ness and use Mr. Laise to review the few instances of the prior patented art, to which we refer, and if your Honor and Mr. Clark will permit, I have three very short fact witnesses, that I would like to dispose of before we go into the patents with Mr. Laise.

The Court: No objection?

Mr. Clark: No objection.

ENRY B. NORTH, called as a witness in behalf of the ndant, being first duly sworn, testified as follows:

Direct examination.

By Mr. Darby:

reside in York, Pa. I am a manufacturer of chemicals, ecially tungsten and molyolenum compounds. I have n in business for myself along this line since 1921. The ne of my company is The North Metal and Chemical mpany. That is a Pennsylvania corporation. I am sident—Treasurer.

We manufacture and sell tungsten compounds to manu- turers who take those compounds and fabricate them o finished products.

The customers are more or less irregular, but amongst r customers we mention Callite Products Company, Sy- n Wire and Contact, Westinghouse Lamp Company.

Q. 9. Do you know that the tungsten compounds that you ke and sell to them are for the purpose of forming fila- nts in incandescent lamps?

A. Yes, I do.

Q. 10. Did you, at my request, transmitted to you through ol. 244] Mr. Padowicz make a tungstic acid recently?

A. I did.

Q. 11. Are you familiar with patents?

A. I am, being interested in all tungsten and molybdenum mpounds.

Q. 12. What were the instructions that you received as how this tungstic acid was to be produced?

A. The order came for the production of nine or ten unds of tungstic acid exactly as prescribed in the Pacz tent.

Q. 13. Do you recognize this patent, No. 1,410,499, as e Pacz patent to which you refer?

A. Yes, sir, this is the patent.

Q. 14. Did you comply with those instructions?

A. Very carefully.

Q. 15. What did you do with the material that you made, e eight or nine pounds you refer to?

A. The finished material was delivered to Mr. Padowicz r his work.

Q. 16. In your regular manufacture of the tungstic compounds for commercial sales as distinguished from this special lot, do you manufacture the tungstic compounds in the manner described in that patent?

A. No.

Cross-examination.

By Mr. Neave:

X Q. 17. Just what was it that you delivered to Mr. Padowicz?

A. Tungstic acid, a batch of nine or ten pounds of tungstic acid made according to the specification of the Pacz patent.

X Q. 18. Just tell me how you made that, if you will.

A. Well, I made that exactly according to the specification, in which, in the first place, we fused 1400 grams—made a mix of 1400 grams of commercial tungstic acid, [fol. 245] with 620 grams of commercial sodium carbonate, 620 grams of commercial potassium carbonate and 300 grams of commercial sodium nitrate. That mix was treated with a little water and made into a paste. The paste, as directed, was dried on a hot plate, and then fused by torch. The resulting melt dissolved in six liters of water.

That was solution A.

The solution B is of a fusion made with 180 grams of commercial silicic acid, 620 grams of commercial potassium carbonate, 150 grams of commercial sodium nitrate, if I have those figures correct in my mind. That was made into a paste in similar manner, dried on a hot plate, fused with a torch, and then dissolved in water.

Those two solutions were used in a mixture for precipitation of the acid. According to the directions, we used 250 cubic centimeters of solution A with 3000 cubic centimeters —I beg your pardon. I think they are 250 cubic centimeters of solution B with 3000 cubic centimeters of the tungstic solution. The tungstic acid was precipitated by pouring it through a funnel into a boiling solution of 1500 cubic centimeters of concentrated hydrochloric acid, and 1500 cubic centimeters of water. The tungsten solution was added, also had been heated, steam heated and boiled.

X Q. 19. Then was it the precipitate that you delivered?

A. The precipitate, of course, was washed as prescribed and dried. It was the dried precipitate which was sent.

X Q. 20. How much did you wash after you mixed the A and B?

A. The washing is rather indefinitely described. It says, directs you in the patent, to wash until it becomes milky. We followed that as closely as we could. We washed as [fol. 246] many times as we could, until it became milky. If the washing goes too far, it is practically impossible to do anything with it. It will not settle.

X Q. 21. Did you make any analysis after washing?

A. I did not.

Redirect examination.

By Mr. Darby:

R. D. Q. 22. Were you connected in any way with the plaintiff General Electric Company or with the defendant Wabash Appliance Corporation?

A. In no way.

(Witness excused.)

Henry N. Padowicz, called as a witness in behalf of the defendant, being first duly sworn, testified as follows:

Direct examination.

By Mr. Darby:

I reside at Bloomfield, New Jersey. I am a graduate of the Rensalear Polytechnic Institute. Received a degree in chemical engineering, Ch. E., in 1928. In my senior year I majored in metallurgy and did research work in this subject in connection with my graduation thesis.

I was employed by the Westinghouse Lamp Company, for six and a half years, from January, 1929, to the latter part of May, 1935.

Immediately after that, I was employed by the Syrian Wire and Contact Company and I have been in their employ ever since.

By the Westinghouse Lamp Company I was employed as [fol. 247] a metallurgical engineer in the first year and a half in the metallurgical laboratory of the experimental department of the wire drawn division. After that, when the head of this department left I assumed charge of this labo-

ratory, and then for the three and half years succeeding that, I was assistant superintendent of the wire drawing division of the Westinghouse Lamp Company.

I am employed by the Syrian Company as metallurgical engineer in charge of the research and experimental work. I am the Mr. Padowicz that transmitted Mr. Darby's request to Dr. North.

Q. 6. Did you receive the tungstic acid that Dr. North transmitted to you pursuant to your instructions?

A. I did, I received a special batch of tungstic acid from Dr. North.

Q. 7. What did you do with it?

A. I took the tungstic acid and under my supervision it was processed similarly to that stated in the Pacz patent, namely, I ignited this tungstic acid, and then reduced this in hydrogen by what Pacz calls his preferred method, to make solution B. From that I obtained tungsten powder. This powder*ed* was sieved, pressed and sintered to form a treated tungsten ingot. It was then squeezed and drawn to fine tungsten wire suitable to make a 100 watt filament. This wire was then coiled and made into a filament for a 100 watt lamp. I flash aged this lamp in a base down position. After flash ageing——

Q. 8. What flash ageing process did you employ?

A. We took the lamp—we bring it from zero up to 150 volts in one-half minute. We then hold it at the peak volt-[fol. 248] age of 150 volts for another half minute. And that consists of our flash ageing process. This filament was flash-aged with the lamp in a base-downward position. After the ageing it assumed a downward droop of about one millimeter, or one millimeter and a half, from a straight line drawn between two consecutive supports.

I then took this lamp and burned it at its base-up position at 140 volts for one and a half hours. After this procedure the curvature of the filament had reversed itself and sagged down to a distance of one millimeter between a straight line drawn between two consecutive supports.

This figure is the average for several lamps. At that point I broke open this lamp and took out the filament and mounted it and polished it and etched it and examined it structurally and then made some microphotographs of the same.

Q. 9. And is the one or one and a half or two millimeter sags that you refer to, that you notice in these lamps, the same in proportion as if the filament was in a hairpin shape, or is there a difference in the character of sag?

A. There is a difference. What I used was a regular 100-watt, 120-volt lamp, which is of standard construction.

Q. 10. Did you say that you made micrographs of the filament?

A. Yes, sir.

Q. 11. And are these the microphotographs that you refer to, that I now hand you?

A. Yes, they are. These two, plates A-15 and A-16, are photographs of the wire made according to the Pacz Patent 1,410,499.

Q. 12. Will you please describe, insofar as we are concerned with the subject of crystalline structure, its con- [fol. 249] tour and shape applicable for the purpose of preventing offsetting and sagging. Describe the crystalline structure of those filaments.

A. I would say this filament was very poor from the present interpretation of a good non-sag structure. It has some elongated single crystals with interlocking grain boundaries, but these are few. It has many fine block type rings which are very detrimental to sagging characteristics in a lamp.

The lamp which is entirely of single crystal interlocking type, after it has been flash-aged, it will not droop, it will maintain its position no matter whether the lamp is burned with base-up or base-down position.

Mr. Darby: I now offer in evidence microphotographs produced by the witness and hereinbefore marked for identification Defendants' Exhibit I.

(Defendants' Exhibit I for Identification marked in evidence.)

Q. 13. Have you samples of the lamps that were made?

A. I have.

Q. 14. Will you produce them, please?

A. Yes, sir. (Witness produces five lamps.)

I have here a lamp made from the Pacz wire, burned according to the flash-ageing procedure in a downward position, and the filament has assumed a downward droop of one millimeter.

Q. 15. You mean made from the tungsten oxid in the manner you have described you obtained from Dr. North?

A. That is correct.

Mr. Darby: I offer that lamp in evidence.

(Received and marked Defendants' Exhibit SS.)

[fol. 250] Mr. Darby: Your Honor, I understand that is a lamp which first sagged in one direction on the flash-ageing, and then sagged in the opposite direction.

The Witness: This lamp which has just been flash-aged, as I described, in this position (indicating.)

This is a lamp (indicating) made in exactly the same way, and it was then burned base up for one and a half hours at 140 volts, which is equivalent to a normal burning of ten and a half hours. The filament has completely reversed itself.

The Court: Was this burned base up or base down (indicating)?

The Witness: Base up.

Mr. Darby: I offer this lamp in evidence.

(Received and marked Defendants' Exhibit TT.)

Q. 16. Referring to this lamp, Defendants' Exhibit TT, am I correct in understanding that the lamp was flashed, base down, and burned base up?

A. After flashing base down, this filament was actually in a downward droop position. It was burned base up, and the filament, which was originally in a downward position, reversed itself and took this droop of one and a half millimeters.

In other words, the lamp, Defendants' Exhibit TT, was in substantially the same condition before I burned it, subsequent to flashing, as is illustrated in the lamp, Defendants' Exhibit SS, with respect to the shape of the filament. [fol. 251] Then to further bring out the sagging characteristics of this filament, I took a lamp made of exactly the same wire, made into a lamp at exactly the same time, and I flash-aged it, base down. At that time it had a downward droop. I then took that lamp and burned it base up for one and a half hours at 140 volts, which is equivalent to a normal of ten and one-half hours. The curvature of that lamp then assumed a downward droop of the same position as the pre-

vious lamp. I then took that lamp and again burned it base down, and it assumed a curvature completely reversed.

In other words, in that lamp the curvature of the filament reversed itself twice.

Mr. Darby: I offer this lamp in evidence.

(Received and marked Defendants' Exhibit UU.)

The Witness: I have here a lamp made exactly of the same coil and same wire which was flash-aged similarly as described before, and then burned in a base-down position for the equivalent of 115 hours, actually twelve hours at 240 volts, and it shows a sag of two and a half millimeters.

Mr. Darby: I offer this last lamp in evidence.

(Received and marked Defendants' Exhibit VV.)

Q. 20. Mr. Padowicz, did you also at my request make some doped wire in which the dope consisted of boric acid?

A. That's correct.

I took one kilo or 1,000 grams of pure tungstic acid and to that I added 12½ grams of fused boric acid as specified [fol. 252] by Pacz in his disclaimer. I dissolved this in 500 c.c. of water, and added that to the pure tungstic acid, and mixed them thoroughly, tried it, and then ignited and reduced it to a tungsten metal, similar to Pacz's description in the preferred method "B."

Under my supervision the tungsten powder was then sieved, pressed and sintered to form a tungsten ingot. This ingot was then swaged and drawn to wire of such convenient size as is required by 100-watt, 120-volt lamp. I then took these lamps and flash-aged them in our regular procedure, which is in a base-down position, and put it through our regular test procedure for determining whether or not the wire has good sag characteristics.

This lamp was then burned in a base up position for one and a half hours at 140 volts which is equivalent to normal burning of 110 hours. After this procedure the filament had a sag of .6 of a millimeter. I then took this lamp broke it up, mounted and polished and etched, and made microphotographs.

The two microphotographs at the bottom of Defendants' Exhibit I are the photomicrographs which I have referred to.

Q. 24. From the viewpoint of necessary qualities for offsetting or for prevention of offsetting and of sagging, will you please compare the crystalline structure of the boric acid doped filament and the Pacz filament?

A. It was very similar. There is essentially no significant difference between them.

I have likewise made lamps with a boric acid doped filament.

Q. 26. Will you produce them?

[fol. 253] By the Court:

Q. 27. What are these, pictures of the doped filament?

A. Those are pictures of this filament (indicating).

Q. 28. Of the doped filament?

A. Of the boric acid dope.

Q. 29. What is this, a picture of something else?

A. This one here is a picture of this filament.

Q. 30. Is this a picture of a doped one, too?

A. No, this is a picture of one that was made by Dr. North according to the Pacz patent.

Q. 31. Are these two photographs different, different wires?

A. No, these are exactly the same. They are just different prints.

Q. 32. Is this the Pacz one or is this the doped one, or are they the same?

A. No, these are the Pacz.

Q. 33. The doped ones are the Pacz?

A. These two are the boric acid doped.

Q. 34. And that is so of this one, and this other one?

A. Yes, this whole chart is an exact reproduction.

Mr. Darby: That is just an extra copy that I gave to your Honor.

The Court: The bottom one is doped, and the one on the top is not?

Mr. Darby: The bottom two.

The Court: The bottom two?

Mr. Darby: Yes.

I might make that clear. Both of them are doped. The upper two microphotographs are doped in accordance with the patent in suit, and the bottom two are——

The Court: Yes, I understand that.

[fol. 254] Mr. Darby: The bottom two are doped.

The Court: I had in mind they were all of the same wire. The top two are of one wire, and the bottom two of another wire.

Mr. Darby: Yes, one is what is claimed, and the other what is disclaimed.

A. I have here this lamp you asked for.

By Mr. Darby:

Q. 35. This is, as I understand it, the lamp that was made with the filament that was doped with boric acid?

A. That is correct.

Q. 36. And has been burned one and a half hours at 140 volts.

Mr. Darby: I offer the lamp in evidence.

(Marked Defendants' Exhibit WW in evidence.)

Q. 37. Will you please compare the degree of sag in the lamp, Defendants' Exhibit WW, containing the filament made with the boric acid doped wire with the degree of sag in the lamp, Defendants' Exhibit TT, made with the Pacz wire of the patent in suit as claimed?

A. The one with the boric acid has slightly less sag than that of the Pacz. The one with the boric acid, in average determination of similar lamps was about .6 millimeters sag; that of the Pacz ranged from one millimeter to one millimeter and a half.

Q. 38. Is there any difference in the offsetting present in the two?

A. These particular tests are short tests to determine the sag characteristics. We had some similar lamps which [fol. 255] were burned to full completion, and both of them showed some offsetting after approximately 700 hours equivalent.

Q. 39. About the same degree on the offsetting?

A. They are about the same degree.

Q. 40. Are you familiar with the Scoular patent, No. 1,104,557, granted July 21, 1914?

A. I am.

Q. 41. Did you make some filament, some wire for use as filament strictly in accordance with the teaching of this Scoular patent?

A. Yes, I did, that is, I added exactly the same amount of material in the same ratio to pure tungsten powder as specified by Scoular in his patent.

Q. 42. What did you do with the wire thus produced?

A. Under my supervision that wire was made into lamps and tested similar to those—similar to our regular test procedure.

Q. 43. That is, similar to the test procedure you described with respect to the other lamps?

A. That is correct. I made microphotographs after one lamp had been burned the equivalent of 115 hours at normal voltage. These are the photomicrographs of those lamps.

Q. 46. Will you please compare the crystalline structure as to the contour, shape and size and any other characteristic effects on offsetting and sagging with the photomicrographs of the Pacz wire filament?

A. The structure of this wire is similar to Pacz. In addition, it had a much larger grain size as to the extent of the size of the elongated single crystal. It also had some traces of the interlocking grain boundaries. After burning one and a half hours at 140 volts, this sagged in a similar manner to the boric acid doped material made according to the Pacz patent.

[fol. 256] Q. 47. Have you the lamps that you tested?

A. I have a lamp. I tested just this lamp for those sagging properties.

Q. 49. Will you produce that lamp, please?

Mr. Darby: While you are doing that, I will offer in evidence the microphotograph just referred to by the witness.

(Marked Defendants' Exhibit XX in evidence.)

This is the lamp which was burned for one and a half hours at 140 volts.

Mr. Darby: I offer the lamp in evidence.

(Marked Defendants' Exhibit YY in evidence.)

Q. 51. In the production of the wire, was it squirted or drawn?

A. It was drawn wire.

Q. 52. And did you also make up a filament doping the tungsten with silicon tetrachloride?

A. I did. I made microphotographs of it. These are the microphotographs.

Mr. Darby: I offer the microphotographs in evidence, they having heretofore been marked Defendants' Exhibit H for Identification.)

(Defendants' Exhibit H for Identification received and marked in evidence.)

Q. 55. Can you produce the lamp which you used?

A. This is the lamp which I made from this tungstic acid which I doped with silicon tetrachloride. It was flash-aged in the base-down position, and then burned for one and [fol. 257] one-half hours at 140 volts in a base-up position. The sag, in this particular case, was much less than that of Pacz wire, it was in the order of .4 millimeter sag between two consecutive supports.

Mr. Darby: I offer this lamp in evidence.

(Received in evidence and marked Defendants' Exhibit ZZ.)

Mr. Darby: You may inquire.

Cross-examination.

By Mr. Neave:

X Q. 57. This lamp, Defendants' Exhibit ZZ, do I understand the wire was doped with silicon tetrachloride, is that correct?

A. Yes.

X Q. 58. And did you make any life tests of this type of lamp, for offsetting?

A. We did.

X Q. 59. And what did those tests disclose?

A. After approximately about 800 hours there was very slight offsetting in some of the lamps.

X Q. 60. How about the lamps you made up in accordance with the Scoular patent, as you so testified?

A. We have not completed the life test in those lamps, that wire was completed only about two days ago.

X Q. 61. How long have those lamps been burning?

A. They have burned about the equivalent of three to four hundred hours.

X Q. 62. Now, in regard to the lamps that you made up in accordance with the Scoular patent, were you requested by Mr. Darby to make up these lamps in accordance with that patent?

A. I was requested to make up tungsten wire from tungsten metals to which added material in exactly the same proportions as that stated by Scoular, had been added.

[fol. 258] X Q. 63. And then what did you do?

A. I took pure tungsten metal and to that I added sodium silicate in the proportions as stated by Scoular. I actually used "C" brand sodium silicate, as manufactured by the Philadelphia Quartz Company, which is very similar and does not vary more than about one per cent in composition.

X Q. 64. How much did you add?

A. I added on the ratio of 24 grams of this to 120 grams of pure tungsten metal.

X Q. 65. And then what did you do after you added it?

A. I dissolved that in distilled water and thoroughly mixed it with the pure tungsten metal. I then dried it and during the drying I continuously stirred it to insure an intimate mixture of the same and to make sure that the material did not cake.

I then took that dried material and pulverized it and sifted it and pressed it and sintered it and formed a fully treated tungsten ingot. This material, under my supervision, was then swaged and drawn to wire..

X Q. 66. What was the size of the wire?

A. The size of the wire was a little over twelve milligrams, which is the same as that required by a 100-watt, 120-volt filament.

X Q. 67. Does that apply to all the other lamps put in evidence here?

A. That is correct.

X Q. 68. What is the distance between those supports in all of these lamps, are they the same?

A. Not exactly the same.

X Q. 69. What is the distance between supports in the Scoular lamp?

A. I did not measure the actual distance between supports.

X Q. 70. In any case?

A. In any case.

X Q. 71. It is my understanding of your testimony that [fol. 259] you stated that the crystals shown in figure 2 of Defendants' Exhibit I were small crystals so that they showed that they did not have satisfactory sag characteristics, is that correct?

A. (Examining.) That is correct.

. 73. Now, if those had been larger crystals, would
y they would have satisfactory sag characteristics?
If those were larger crystals of the elongated inter-
g type, extending over several turns, they would have
atisfactory for sag.
. 74. For instance, such as is shown in Plaintiff's Ex-
30?
These I would say are not comparable, the magnifica-
s 750 diameter, where the ones I have there the magni-
on is 200, and I cannot see the full extent of the length
crystals.
. 75. You will find some other magnifications if you
on turning the pages.

e Court: Do you find any?
e Witness: I think the figure here WF-7, on page 19,
shows long crystals of the single crystal interlocking
dary type. That, however, is not comparable either,
s a 25-watt lamp, and in small wires the crystals are
ly somewhat longer and they flash over much easier to
ull diameter of the filament in question.

. 76. But those are long crystals?
They are long crystals.
. 77. Will you turn to page 21?
Yes.
. 78. Can you tell from those sections whether there
ong crystals there?
260] A. I can tell that the crystals' size extends
s the full diameter of the wire, but I cannot actually
mine the length of them.
. 79. Your answer in regard to page 19 would apply
ge 18 as well, would it not?
Yes, it is very similar.
. 80. And to page 17?
That's correct.

Witness excused.)

JOSEPH SPINA, called as a witness in behalf of the defendant, being first duly sworn, testified as follows:

Direct examination.

By Mr. Darby:

I reside at 2770 East 23rd Street, Brooklyn; 44 years old. I have been a lamp man for about 25 years, actually manufacturing lamps. I am the man who actually fills the lamps. I am employed in that capacity at present by Lightmore Appliance. In 1917 I was with the Independent Lamp and Wire Company. Prior to that time I worked for the Westinghouse Lamp Company. I left the Independent Lamp and Wire Company in 1918. I am familiar with the manufacture of the gas filled lamps that were manufactured by the Independent Lamp and Wire Company while I was with them.

Exhibit CC is the lamp made in Independent Lamp and Wire Company while I was there. It is one of the lamps that was made there. I can tell by a number of things that are familiar to me.

[fol. 261] Q. 16. Can you tell at what period of your work with the Independent Lamp and Wire Company it was made?

A. Well, I should say about—yes, about 1913.

The Court: 21 years ago, you can remember a lamp?

The Witness: Yes, sir; there is a machine that we got at that time that did some of the work there, that I can tell by it.

The Court: You mean it was a machine that made lamps all alike? You could not look at that lamp and say that you saw that lamp made?

The Witness: Not this. Previous to that time, these lamps was made different. The button was made different.

The Court: You do not get the point I am making. You could not tell that you saw that particular lamp made?

The Witness: Not this lamp, no, but lamps were made like this at that time.

Mr. Darby: 1916.

The Court: How many lamps were made a day?

The Witness: Oh, at that time, about four or five thousand a day.

The Court: You did not see every one made, did you?

The Witness: No, but I could tell——

The Court: You did not see every one of the four or five thousand made, did you?

The Witness: Well, at one stage or another, I did.

[fol. 262] The Court: You did not see the lamp when it was finally made; you saw part of it.

The Witness: Yes, I saw part of it——

The Court: All you can say is that is a lamp like one of those four or five thousand?

The Witness: Made at that time, yes.

Q. 17. I hand you Defendants' Exhibit Z, and ask you if you can state—if you can recognize that lamp like the lamps manufactured while you were with the Independent Lamp and Wire Company?

A. Yes, this is the construction that we used at that time about 1916.

The Court: When did you leave the Independent Lamp and Wire Company?

The Witness: 1918.

Q. 19. Have you, in your possession a lamp that you made at that time, have you since, while you were connected with the Independent Lamp & Wire?

A. I have. I had this lamp since 1915. It has been in my home ever since. It has been used maybe two or three hundred hours, roughly.

Q. 23. Will you produce that lamp, please?

A. (Witness complies.)

Q. 24. You can positively swear that this lamp was made in 1915?

A. Yes.

Q. 25. It has been in your possession since that time?

A. Yes.

Q. 26. And has been used by you up to at least several hundred hours, is that right?

A. Yes.

[fol. 263] Mr. Darby: I offer the lamp in evidence.

(Marked Defendants' Exhibit AAA in evidence.)

I am not connected with the General Electric Company in any way, nor with the Wabash Appliance Company, I am not directly interested in any way in this litigation between those two companies.

Q. 30. What do you mean by that?

A. Well, maybe I will have to stop making lamps.

Q. 31. Was this lamp one of your regular run of production or was it a specially constructed lamp?

A. Yes, that was taken out of production when they first started to make them small lamps.

Cross-examination.

By Mr. Clark:

X Q. 32. As I understand it, with respect to this lamp CC, your testimony is that it was not made before 1916?

A. That is right.

X Q. 33. Because the construction of it leads you to believe that it was made by a machine that was installed in 1916, is that right?

A. That is correct, latter part of 1915—1916, I should say. I am almost sure of that.

X Q. 34. And the same is true of this lamp Z, you do not think this was made before 1916?

A. It was made about that time, about 1916.

X Q. 35. All you know is it could not have been made before that, because the construction which it embodies was adopted at that time, is that right?

A. That is right.

X Q. 36. This lamp which you say was made in 1915, [fol. 264] how do you tell from its appearance that it was made in 1915?

A. Well, the construction of it, and the inserting is done by hand, we had no machines to do it at that time, and after that time we got the machines which produced the different types.

X Q. 37. The other type, that is Exhibit CC?

A. That's right, and I also know at the time that I took them home when I first started making them.

X Q. 38. How did you happen to keep them all this time?

A. Well, it has been in a fixture ever since, and it has been used very little.

X Q. 39. Used in a fixture?

A. In a table lamp. It has been used ever since.

X Q. 40. It has been used ever since?

A. Yes, in fact I took it out of there last week.

Mr. Clark: That is all.

(Witness excused.)

CLEMENTS A. LAISE, recalled.

Mr. Darby: Your Honor, I might state that we have obtained another one of the lamps like Exhibits RR and QQ, which were burned, and hence losing their initial position after flashing.

The Court: That is the one I told you to bring this morning?

Mr. Darby: Yes, sir. So I offer this lamp in evidence. [fol.265] It is made exactly like Exhibits RR and QQ and has been subject to flash-burning only.

The Court: About how long, less than a minute?

The Witness: About a half a minute.

(Received and marked Defendants' Exhibit BBB.)

The Court: I understand it is stipulated by you gentleman that the electrician in the building burned these two exhibits, Defendants' Exhibits KK and LL, for five hours, and now the witness may state what he finds with regard to the filament after that burning of five hours.

Before you testify, Mr. Laise, look at them. Take them one at a time. You come up, too, Dr. Jeffries, and examine them, because I want to ask you some questions about them also.

The Witness: Exhibit LL, which was made with the improved GE 218 type wire, after burning five hours, shows that the V-shaped loops have a droop or sag quite substantial, considering the period of burning was only five hours.

The Court: Well, is that known as a commercial sag or not—"a substantial commercial sag"? That is the phrase. Would you say that is a commercial sag or a non-commercial substantial sag?

The Witness: For a lamp burning in a horizontal position this would be a commercial sag—a substantial commercial sag, a commercial non-sag.

The Court: All right.

[fol. 266] By Mr. Darby:

Q. 157. In other words, that would be considered as a commercial non-sag filament?

A. If it had been burned in a horizontal position.

The Court: It is stipulated that it was burned in a horizontal position, is it not?

Mr. Darby: That's right.

The Court: That is the way the building electrician burned them.

Mr. Darby: Yes.

Q. 158. And the next one?

A. Exhibit KK which was also burned in a horizontal position, having the improved type 218 Pacz filament, also indicates it is a commercial non-sag filament.

Mr. Darby: Of course, your Honor using the term "commercial non-sag" in the trial is one thing, and as used by Pacz is another.

The Court: Well, you have to have a line somewhere. These experts will not try to draw a line with me. That applies to both of them.

Q. 159. Now, I want to crystallize this one point in connection with Exhibit LL. Am I correct in understanding what you said, that while the saw-tooth filament in Defendants' Exhibit LL, has shown a sag it would nevertheless be considered as commercially acceptable?

A. It is commercial non-sag.

The Court: Just one question: Is the wire in those large lamps any larger than the wire in the small lamps?

[fol. 267] The Witness: Yes, sir, as the wattage gets bigger the wire gets very much bigger.

The Court: I thought that. I had the idea that large lamps had larger wire, but my eyesight is not any too good.

Mr. Darby: I should like to offer in evidence a folder containing the following instances of prior patented art:

Patent to Schaller, No. 1,104,557, patented July 21st, 1914.

Patent to Kruger, No. 1,154,701, patented September 28th, 1915.

Patent to Schaller, No. 1,256,929, patented February 19th, 1918, and application filed May 16th, 1914.

Patent to Schaller, No. 1,256,930, patented February 19th, 1918, application filed May 16th, 1914.

German Patent No. 283,071 of 1914, with a translation.

(Folder received in evidence and marked Defendants' Exhibit CCC.)

The Witness: I have been working on patent matters ever since 1916, since the start of the suit by the General Electric Company against the Independent Lamp and Wire Company on the Coolidge patents, and assisted Mr. Billings in preparing that Independent case at that time.

I also worked with Mr. Holland on a tungsten filament case covering the Lederer patent, and assisted him in preparing that case by the General Electric Company against the Ceco Manufacturing Company.

[fol. 268] I also worked, while in Toledo—the Save Electric was being sued on several patents on tungsten filament and tungsten wire—and I assisted their Toledo attorneys in preparing the defense on the filament we were manufacturing for incandescent lamps for use in Save lamps.

I also testified in the patent case of the General Electric against the Daylight Lamp Company and assisted in the preparation of the patent case of the General Electric Company against the Service Lamp Company in Canada.

I personally have taken out between thirty and forty patents, filed in the Patent Office, and in which I assisted my attorneys in prosecuting through the patent office.

The Court: Did the trials of these cases necessitate you, in preparation, reading a great many patents?

The Witness: Yes, it did.

The Court: And in interpreting them?

The Witness: It did. I acted as expert for the Ceco Company.

Q. 163. As patent expert, patent and practical expert in that case?

A. Practical and expert.

The Court: Did you testify in these cases, as a patent expert, interpreting patents?

The Witness: In that case, I did, yes, sir.

The Court: Are you satisfied now, Mr. Clark?

Mr. Clark: I think that is as far as he can go.

The Court: You may proceed.

[fol. 269] In all of these cases, the patents that I studied, pertained to tungsten filaments. I am familiar with the Pacz patent in suit as well as its claims.

Q. 167. Will you please turn to the Coolidge patent, which has already been marked in evidence Plaintiff's Exhibit 2,

and point out its relevancy or want of relevancy with respect to the subject matter of the Pacz patent in suit, in so far as production of a sagless filament is concerned?

The Court: And non-offsetting.

A. The Coolidge patent claims, in his claim 16, the process which consists in producing tungsten containing beneficial additions, forming into a billet, sintering it at a high temperature and mechanically working it a great number of times at high temperature and reducing the temperature during the working operation.

In claim 13, the Coolidge patent covers the process which consists in firing tungsten oxide in refractory crucibles of the Hessian or Battersea type, reducing the oxide to coarse metallic powder; conglomerating the powder into a coherent body, sintering the body and then subjecting it to hot mechanical working.

Claim 15 refers to the preparation of the tungsten body, which consists in firing the tungsten oxide in refractory crucibles of the Hessian and Battersea types, subsequently reducing the oxide to metallic tungsten powder.

These claims in general refer to processes or a process of adding beneficial additions to the tungsten to prevent [fol. 270] offsetting and at that time the type of filament mostly used was a straight wire type filament, and in that it also prevented sagging.

Q.168. Now, Mr. Laise, proceed with the consideration of the Coolidge patent, having in mind what is stated by the Pacz patent in suit. That consists of the inventive idea of producing a sagless and a non-offsetting filament. Do I make my question clear?

A. I think I do know what you are trying to get at.

The Coolidge patent essentially describes the actual manufacture of tungsten filament and was the basic patent for the manufacture of tungsten filament and in the disclosure it describes in general the addition of beneficial additions to tungsten to prevent offsetting and to improve the flexibility of the filament.

It describes several processes for doing that. It describes a thoriated process, which means that they added a thorium oxide to the tungsten oxide, and that acted in a beneficial manner in the filament in burning. It describes the Battersea method, by which they meant that there was a certain

amount of beneficial additions distilled out from the Battersea crucible into oxide and that produced a beneficial effect, prevented offsetting and improved the quality of the filaments.

Now when these beneficial additions were made, especially to a tungsten oxid, that was precipitated in a normal manner from a sodium tungstate solution, then the ingredients in that oxid was the remaining ingredients in the oxid—there was a certain amount of alkali and a certain amount of silicate, if the Battersea method was used, and [fol. 271] Coolidge states—"I prefer to employ the treatment above described of simply firing the tungstic oxid in a Hessian or Battersea crucible, for this treatment is simple, successful and reliable."

I was quoting from page 7, line 31 to line 35.

Now this Battersea method was an easier method to carry out. Here in the States most of us used the thoriated method because it was worked out by the General Electric Company, and they controlled the situation, and naturally set the style. In other countries they preferred to use the Battersea method because it was simpler and easier.

On the other hand, the Battersea method was not the exact method of adding beneficial additions. Sometimes the crucible would give off a lot of its volatile matter and the oxid would be doped to a much higher degree than at other times, and the result would be that certain lots of filaments produced would be non-sagging in the lamp and at other times you would have the result that would show considerable sag, when made into coils in coiled filament lamps.

Now as the result, or because of that, it was the general practice in some of the independent factories, particularly, to test every lot of wire commercially.

In other words, we would put lots of about 50 kilos of metal through at a time. That metal would be uniform for that particular amount, which would probably make hundreds of thousands of lamps, or would be sufficient for hundreds of thousands of lamps. That lamp would be tested by actually making the coils out of the wire and test-[fol. 272] ing it to see if the filament would stand up. If the filament did not materially sag, that material was used for the production of coiled filament lamps, and particularly for the production of the gas-filled lamp which was covered by the Langmuir patent, and according to which also a tremendous number of lamps were produced at that

time—the coiled filament lamp, and in order to practice that Langmuir patent it was necessary to have a non-sagging filament, to be able to live within the terms of the claims of that patent, because if there was excessive drooping in the coil used in the Langmuir patent, then those lamps were no longer within the sphere of these claims.

The Court: Do you find under the Coolidge patent the independents used practically the same method as provided under the Coolidge patent? You said something about the independents.

The Witness: At that time there was quite a question as to whether this——

The Court: No, did the independents make under Coolidge patents?

The Witness: A number of them.

The Court: I am asking you if there were independents that did.

The Witness: Quite a few used the modified Coolidge patent.

The Court: I don't care what you did—did independents make under the Coolidge patent?

The Witness: Independents manufactured under the Coolidge patents.

[fol. 273] The Court: Mr. Clark, was the Coolidge patent ever sustained?

Mr. Clark: Yes, your Honor.

Mr. Darby: That is the patent I told your Honor was sustained by Judge Morris and then a number of years later invalidated.

The Court: It was sustained by him and then modified in part?

Mr. Clark: The result was that the process claims were held valid and the product claims were held invalid. That was near the end of its life.

Mr. Darby: The original decision was long prior to the end of its life.

The Court: As I recall it, it had been sustained and then in part rejected by the same Judge?

Mr. Darby: The same Judge rejected it in toto, and it was modified as to the process claims and held to be valid, but not infringed. Not only was this Battersea Coolidge process used by independents, but it was also used by the Westinghouse Company as licensee.

The Court: All right, go ahead.

The Witness: I could make a very simple comparison here and then you can ask questions.

The Court: You better do it counsel's way.

Q. 170. I will ask you one or two very specific questions, and then you can add your statement of comparison if you wish. Now with respect to the chemical character of [fol. 274] these beneficial additions, will you compare the beneficial additions specified or obtained under the Coolidge patent process with the specified additions specified in the Pacz patent in suit?

A. The specified additions under the Coolidge patent, when using the Battersea method was an ingredient in part of the Battersea crucible which consisted of silica, some aluminum, and some alkali metal. In addition to that the tungsten from which the filament was made was precipitated from an alkaline salt, and that oxid usually contained a certain amount of residual alkali so that the ingredients in a way were almost the same as in the Pacz patent in suit. The main difference is that Pacz in his patent stipulates a certain method of incorporating these ingredients more intimately.

The Court: That is the process, the method?

The Witness: The process, the method, and in fact it is only a process method or a process patent, because the product really already existed—not the improved Pacz of today, and this wire was made according to these specifications.

The Court: Now where is the difference?

The Witness: When this patent was filed, Pacz claimed in the preferred form, reading from page 1 of the Pacz patent No. 1,410,499, line 24 to line 36, wherein he says:

"In the preferred form of my invention I bring into [fol. 275] intimate association with tungsten a material which will have the desired influence upon the grain growth of the metal. I precipitate, simultaneously, compounds from which the metal is to be directly reduced with the material or compound which is to accomplish the desired result."

In other words, he made a fusion of these ingredients and then he precipitated oxid, and that oxid as it precipitated

carried these beneficial additions down with it and precipitated some of them in the material, and thereby he incorporated that material more intimately than any other method used before. From that point of view this method may be novel.

The Court: Are the same ingredients used in the Coolidge patent as in the Pacz patent, or if there is a difference, point out the difference to me in the ingredients. Leave the method aside for the moment, please.

The Witness: The Coolidge patent covered general beneficial additions, in general. It did not confine itself to one.

The Court: Any beneficial addition that would work is covered by the Coolidge patent?

The Witness: That is what they tried to cover in their broad claims. That is what was in their mind.

The Court: Well, what do you say the Pacz patent beneficial ingredients are?

[fol. 276] The Witness: According to the Pacz patent he adds to the tungstic and a certain amount of sodium silicate.

The Court: Was that in the Coolidge patent—silicates?

The Witness: Silicates were added in the Coolidge patent.

The Court: All right, go ahead with the next ingredient.

The Witness: That is the main ingredient in the Pacz patent.

The Court: But that was also in the Coolidge patent?

The Witness: It was also in the Coolidge patent, but it was incorporated in a different manner.

The Court: Now, one step at a time. The ingredient in the Pacz patent is the same as the ingredient in the Coolidge patent?

The Witness: That is my claim.

The Court: Are all ingredients in the Pacz patent substantially the same as the ingredients in the Coolidge patent? Now, if you cannot answer my question, you just say so. If you can answer them, you go ahead and answer them.

The Witness: Taking the broadest interpretation of the Coolidge process, I would say that they cover all of the ingredients that Pacz added to his tungsten.

The Court: Is it the difference that Pacz named his ingredients in his patent, whereas the Coolidge patent did not name them?

The Witness: No, both of them—that is one of the main [fol. 277] differences, that Coolidge takes his generally.

The Court: And Pacz takes his specifically.

The Witness: That is correct, in a specified manner.

The Court: We are just talking about the ingredients now. You interpret the Coolidge patent to include the same ingredients as the Pacz patent, is that right?

The Witness: That is correct.

The Court: Now, is the process different in the Coolidge patent over the Pacz patent?

The Witness: No, the process of adding the beneficial addition is different in that the addition is added during the precipitation.

The Court: In the Pacz patent?

The Witness: In the Pacz patent.

The Court: Now, just what do you mean by "during the precipitation"?

The Witness: Well, that is very similar to rain in Pittsburgh, you might say. You have a cold wave coming along, and heavy clouds over Pittsburgh, and a real smoky day, and you would have the rain precipitated and carry down some of that dust. Here you had hydrochloric acid——

The Court: In the Pacz patent?

The Witness: In the Pacz patent. You added hydrochloric acid to the sodium tungstate, containing some sodium silicate and potassium silicate.

[fol. 278] By the Court:

Q. 171. And all those ingredients could have been used in the Coolidge patent?

A. All those ingredients could have been used and were to a certain extent used.

Q. 172. But show me the difference in the process and try to use language that I can understand, will you?

A. That is all there is to the—the essential and vital point that there is to the Pacz patent, that they add their additional—their beneficial addition by this precipitation method and by that means, as he says. Intimately associate with the tungsten, these beneficial ingredients.

Q. 174. Just tell me, supposing you were describing that process to some students in a class, and I think you can, will you tell me just what Pacz does with his material? Supposing I am your student for the moment, and I am, suppose you tell me in language I can understand, what you do under

the Pacz patent, what process do you go through? You take first what?

Mr. Darby: May I interrupt just one moment, please, because I think I see what is troubling the witness, if anything actually is; so far as the manufacture of tungsten wire is concerned, this patent in suit we are not concerned with it.

The Court: I know you are not.

Mr. Darby: All we are concerned with is the addition of beneficial additions.

The Court: That is right.

Mr. Darby: Extraneous matter.

[fol. 279] The Court: As I see it now, and if I am wrong, you correct me, both, this is a process patent?

Mr. Darby: But there are claims for a product as well.

The Court: And you claim for a product as well. Now, that is why I am getting at it in my way. I am going to give Dr. Jeffries a chance later on to tell me where the difference in the product is. I am going to get an issue of fact here, if I can. He says that the products in the Coolidge patent and in the Pacz patent are similar in nature.

Q. 175. Now, you tell me what the process is of making these ingredients into this wire, using me as a student now?

Q. 176. You see what I mean. I see I am getting to where this is pictured right in my mind, after a week of it. You tell me how he does that? Supposing I am a student, you describe it.

A. Pacz gives one illustration as to how he does that, in that he uses——

Q. 177. No, no, you give me your interpretation of what you read in the Pacz patent, as though I were a student. You take the first ingredient, is that right? What is the first thing you take in your hand to make that wire in Pacz?

A. He uses commercial tungstic acid.

Q. 178. Is that liquid?

A. That is——

Q. 179. A powder?

A. I had some exhibits of these powders, if——

Q. 180. Certainly, I would like to have them, if you have the exhibits here.

A. I want to see.

[fol. 280] Mr. Darby: All right, Mr. Laise, get them.

Q. 181. You have talked about tungstic acid?

A. I am sorry——

Q. 182. Which is a liquid or powder?

Mr. Darby: It will be here.

A. It is a powder.

The Court: He can describe it.

Q. 183. How much of that powder do you take?

A. He says, "I use 1400 grams of commercial tungstic acid."

Q. 184. How much is 1400?

A. He stipulates commercial. Now, there is a question of this commercial. Commercial tungstic acid is something you buy on the open market that may contain all kinds of impurities. That commercial tungstic acid may be produced from various types of ore. Now, we have found that if we produce the tungsten from one type of ore, we can get non-sag——

Q. 185. When you say one type of ore, what do you mean?

A. Such as scheelite.

Q. 186. What kind of ore is scheelite?

A. Ore from a certain section of the country that has been contaminated with certain impurities. Scheelite is calcium tungstate. It is a white rock.

No, we have two kinds of ore; we have scheelite and we have wolframite. Wolframite is an iron manganese tungstate, containing iron, manganese, tungsten and silicon, and other earth additions.

[fol. 281] Q. 190. Now, that is a powder that he mixes?

A. That is a rock, and you treat that with sodium carbonate and sodium nitrate, make a fusion and produce alkaline tungstates. And then you precipitate that with acid.

Q. 191. You mix it with acid?

A. Yes.

Q. 192. What kind of acid?

A. Hydrochloric acid.

Q. 193. Under the patent?

A. I have not reached the patent. I am merely telling you how we make commercial tungstic acid.

Q. 194. Various ways?

A. Yes, and they treat it with hydrochloric acid or nitric

acid. This alkaline tungstate precipitates. This commercial tungstic acid really—this expression should be much more specific. In contrast to, for instance, he calls boric acid CP. CP means chemically pure.

Q. 196. Commercial tungstic acid could be made in various ways, so you call it commercial tungstic acid. And you have just described various ways it can be made, is that right?

A. One of the ways. There are other ways, too, that I have not described.

Q. 198. Suppose you go into the next ingredient that is described in the specification.

A. You take tungstic acid, which is yellow in color, and mix it with sodium carbonate.

Q. 199. What is sodium carbonate?

A. Sodium carbonate is just a chemical combination of sodium—a powder, and mix that with potassium carbonate, another powder, one being potassium, and the other being a sodium salt, and mix that with sodium nitrate. And then they make a fusion, it is all mixed together and heated up on an iron plate, and a fusion is produced of these potas- [fol. 282] sium and sodium tungstates. Just a fused mass. This fusion is dissolved in water.

Q. 205. Hot water or cold water?

A. It doesn't say.

Q. 206. It makes no difference?

A. Filtered and diluted to six liters. He gives a certain amount. And this he terms solution "A." Then, he makes a fusion of silicic acid, which is silicon oxid, almost like sand, and commercial potassium carbonate and commercial sodium nitride, also being the same chemicals, and that produces a sodium potassium silicate, and this is also dissolved in water, and he terms that solution "B."

Then, he adds 250 cubic centimeters of this solution "B" which contains alkaline silicates to three liters of solution "A," which contains alkaline tungstates, and he takes that mixture and heats it, and it is poured into boiling hydrochloric acid, which is an acid, and that causes a precipitation of this yellow oxid of tungsten. And then that precipitate carries down with it a certain amount of silica, and if the solution is not washed thoroughly it may contain certain amounts of alkalis.

And then he says this precipitation is allowed to settle, and the liquid is decanted and is filtered and washed with hot water. In other words, that gives the yellow oxid in the precipitate.

And this is then dried out and is ignited in a quartz dish, which is also a silica dish, and is reduced in hydrogen in boats, each boat containing about a hundred grams, the total then produced may be termed the metal which is produced, may be termed metal A. That is his first metal. In other words, that is how he produces the tungsten [fol. 283] powder which he claims is suitable for this method.

Now, he has a metal, a grayish powder of tungsten. Then, he reduces that. He does not say how he reduces that. He does not give any temperatures of reduction. He does not say anything about the flow of hydrogen, and we consequently assume that he practices the standard method of the art for reducing tungsten.

Q. 212. Do you believe that is the secret part of his formula, what you have just spoken about?

A. No, that is not the secret part of his formula.

Q. 213. That is not of importance, not mentioning the temperature?

A. Oh, yes, that is quite important. He does not mention that in the first stage, but what I am getting at is this: That in the Coolidge process, when he practices the Coolidge process, Coolidge also states he reduces the hydrogen at a temperature up to 900 or a thousand degrees Centrigrade—he reduces the Tungsten at a temperature of 900 or a thousand degrees Centigrade with hydrogen.

Now, in the Coolidge process, as we worked it in 1913, and even before that, we usually reduced it by stages. We had a low temperature reduction and we had a high temperature reduction. We reduced at 700 in the first stage, and we produced an oxide with some gray metal powder on its surface. Then, we took those oxides out of the furnaces, mixed them up and reduced them in the second stage at a high temperature with hydrogen flowing through it, and produced a suitable metal.

Now, Pacz states, and the plaintiff may state, this reduction is a part of their process. In his first method he states [fol. 284] nothing about how the metal is produced. He

says this metal may be pressed up and sintered to produce tungsten slugs, which may be drawn into filaments having non-sag or other characteristics hereinbefore stated, and he does that all by the Coolidge process.

Q. 215. Before—you have gotten to this metal powder. What happens after that?

A. We have gotten to the metal powder. That is as far as Pacz went.

Q. 217. So far as the Pacz patent is concerned, that is, so far as he goes, you claim, is that right?

A. Yes, so far as he goes in his first disclosure.

Q. 218. Now, carry that disclosure out, how would you get to the wire under that disclosure. You tell me how you would do it under the Pacz patent.

A. This Pacz patent has nothing to do with wire drawing. He says, "I do it by the Coolidge process."

Q. 219. He claims to make a product which is wire, isn't that right?

A. Yes, but he does not make it really.

Q. 220. Under that patent, can you make a product of wire with that process? You have got to this powder now.

A. Yes.

Q. 221. Well, he doesn't stay there, does he?

A. Then, he says, "I could use"—after this powder, he says, "It is then sieved, pressed into ingots and sintered in the usual way as set forth in the Coolidge patent."

The Court: In other words, after you get to that powder, [fol. 285] he says do it like you would do it under the Coolidge patent and you get this?

The Witness: That is right.

Q. 222. Now, I am showing you Plaintiff's Exhibit 10. He gets a bar of metal like this Plaintiff's Exhibit 10, is that right?

A. Following the Coolidge procedure.

Q. 223. From the time of the powder, from that time on, following the Coolidge procedure, he gets that ingot, such as Plaintiff's Exhibit 10?

A. And he says that ingots produced according to this process usually have fine grains as between 2500 and——

Q. 224. We will get to that in a minute.

A. Well, that is very important.

Q. 225. You get that piece of metal that I have just handed you, similar to Plaintiff's Exhibit 10?

A. Yes, sir.

Q. 226. By that process you have just described?

A. Yes.

The Court: Now, you tell me anything you want to about that.

The Witness: Now, he says that that ingot has a grain structure or grain count of 2500 to 6500 grains per square millimeter. In other words, when this is cut off and etched and examined under a microscope the grain count is 2500 to 6500 per square millimeter. That is what he says in his patent. That is not what they use. I think that Dr. Jeffries testified that they use over 10,000, and I know that the general process is to use a high grain count ingot, a [fol. 286] higher grain count ingot than that.

Q. 229. To that extent, the process is different than that disclosed in the patent?

A. Well, I haven't examined it.

Q. 230. Well, Dr. Jeffries stated that the grain count in that ingot was over 10,000, or approximately 10,000.

Is that right, Mr. Clark?

Mr. Darby: That was the testimony, as I recall it.

The Court: More than that disclosed in the patent also?

Mr. Clark: And some also less, your Honor.

Q. 231. Now, what importance is that grain to that particular article? Is it in the sagging and offsetting, is that right?

The Witness: The grain will, to a certain extent affect the wire quality under certain procedures of heat treatment.

Q. 232. You mean from this point on or before this point?

A. I have this ingot with that grain count and according to some exhibits I have made, which checked up, I actually get that grain count with that process.

Q. 233. What do you get, about 6500?

A. About 5,000.

Q. 234. Then what do you do—do you draw wire from that?

A. Then he says this ingot is worked out by the Coolidge [fol. 287] procedure to draw wire that is hammered and swaged and in a special way, until it is formed into the wire. Now, he does not say anything as to whether this wire is annealed at any of the intermediate stages except that when he says this is the Coolidge procedure and gets the wire which he claims.

Q. 235. In other words, from the time that Plaintiffs' Exhibit 10 is made until the wire is produced under this patent, you say the Coolidge system is followed?

A. That is correct—that is, should be followed according to this patent, but I say——

Q. 236. Now, just a minute. Is there any other process disclosed by him in that patent than the one you have just described?

A. No. It is all taken down by the Coolidge method.

Q. 238. What kind of a wire do you say the patent, the Pacz patent produces under the one you have just read me—does it produce a non-sag, non-offsetting wire?

A. Your Honor, we have not reached that point yet. At that point, when we reach that wire——

Q. 239. This ingot.

A. It is drawn down to a wire by the Coolidge process, and then we have a fine grained fibrous structure of wire, wires unburned showing fine grain fibrous structure.

Q. 240. Now, if you would answer my question, you would not get me off the track. Under that Pacz patent that you just interpreted, what kind of a wire is eventually produced, a non-sagging, non-offsetting wire or otherwise?

A. The wire produced is a fine grained fibrous wire.

Q. 241. Does it sag?

A. We have not reached that. We only make the wire. [fol. 288] After we get the wire, then we come to the manufacture of the coil.

Q. 242. Now, you go from the wire on and, then into the coil—in that patent. Does it advise a new system or does it tell you to go to the Coolidge system from the wire on? In other words, you have a wire, and from that wire you make a filament. Is that right?

A. We have a wire.

Q. 243. Is that in turn a filament, or isn't it?

A. It is going to be.

Q. 244. But it is not at that time?

A. It is not at that time a filament.

Q. 245. Now, we are going to make a filament from the wire.

A. Yes.

Q. 246. What process does he disclose to make that, if it is different from the Coolidge process?

A. The Coolidge process——

Q. 247. From the wire into the filament?

A. The Coolidge process produces this wire and the Pacz process produces this wire.

Q. 248. In the same manner?

A. By the Coolidge process.

Q. 249. In other words, when you have got the wire made from Plaintiff's Exhibit 10, from the time you make the wire into the filament under the Pacz patent, you say you have used the same method as disclosed in the Coolidge patent?

A. Correct.

Q. 250. Now, you finally get a filament under this Pacz patent?

A. He does not say how he gets his filament. He does not say anything how he coils the wire.

Q. 251. Well, you draw the conclusion that because he does not say how to do it, that you do it under the Coolidge [fol. 289] patent, is that what you mean? I will ask you, if after you got the wire, does the Pacz patent tell you how to make the filament, yes or no?

A. It does not tell how to make coiled filament.

Q. 254. Then it does not tell you how to make it under the Coolidge system or any other system?

A. The Coolidge system only produces the wire. We have not made the coil for a filament as yet, and the Pacz patent does not say anything about how that coil should be made.

Q. 255. From the time you get the wire, the Pacz patent does not tell you how to make this coiled filament?

A. No, but then it goes ahead and tells how the coils of that wire should be flashed in lamps, but it does not describe, for instance——

Q. 256. How to make it, but it is flashed—flashed means burned?

A. How the coil should be flashed in the lamp. But you flash the coil after you make it, you must make the coil to flash it.

Q. 258. Now, do you say that under that patent it does not tell you how to make this filament?

A. It does not say anything about the mandrel or how closely it is to be wound or how far apart it is to be wound—it does not go into those details of the filament manufacture, and that is quite vital because——

Q. 259. It does not tell you that, but you have done it yourself—you have made a filament?

A. Yes.

Q. 260. What systems did you use in making the filament of this 218 Pacz wire?

A. We used the standard method.

[fol. 230] Q. 261. Known in the art?

A. Known in the art.

Q. 262. Now, using that Pacz filament that is made from that patent as you have interpreted it, what kind of a wire do you get, a non-sagging, non-offsetting filament or otherwise?

A. When adhering strictly to——

Q. 263. Yes, adhering strictly to the patent in suit that we are interpreting?

A. Pardon me. The next step is to flash that wire.

Q. 264. I don't care what you do with it. It is very vital to me, that question, the answer to it. Take that Pacz patent, and you do everything that you tell me you have interpreted you should do with that—you get the wire, you use the prior art method, and you do eventually get a filament?

A. Yes, sir.

Q. 265. You have gotten it?

A. Yes.

Q. 266. Now, what kind of a filament do you get, one that sags and offsets, or one that does not?

A. In most instances the wire will sag and will be coarse-grained, but it will not resemble those uni-crystals——

Q. 267. I am not referring to them at all. I want your opinion as to what you get generally from that filament.

A. It is a commercial filament that is no better than that produced by the Coolidge process.

Q. 268. You are ahead of me. Under that Pacz patent that you have just interpreted, do you get a commercially substantial non-sag, non-offsetting filament?

A. Certain batches will produce that, and other batches will not.

Q. 269. In your opinion what percentages do and what percentages do not, if you know?

[fol. 291] A. Our first experience was 60 per cent good and 40 per cent bad.

Q. 270. Now, you claim that this 218 filament that is in evidence here is an improvement over the one disclosed in the Pacz patent, is that right?

A. Yes, sir.

Q. 271. You claim this 218 filament is not the filament that you make if you adhere to this Pacz patent?

A. That is true.

Q. 272. And the 218 filament improved is non-sagging and non-offsetting?

A. It is much more so than the other.

Q. 273. Then they must do something with that 218 improved filament that is not disclosed in that patent—am I right in concluding that?

A. Yes.

Q. 274. Now, you tell me whether the Pacz patent, insofar as you have interpreted it there, is an improvement over the Coolidge patent on non-sag and non-offsetting.

A. I consider it only another method of producing the same results.

Q. 275. To all practical purposes?

A. Yes.

Q. 276. Now, will you tell me if the Coolidge patent is an improvement over the Schaller patent in making and producing a wire that is non-offsetting and non-sagging?

A. The Schaller patent and the Schaller filament actually discloses a real non-sag filament. That is a non-sag filament, and that is the type of filament that the industry—the filament industry is trying to attain, and has been gradually approaching, year by year.

Q. 277. Is the Coolidge patent—the filament made under the Coolidge patent—an improvement over the Schaller [fol. 292] patent insofar as non-sagging and non-offsetting is concerned?

A. No, it is not.

Q. 278. You say the Schaller patent is better?

A. The Schaller is an ideal non-sag filament.

Q. 279. Commercially, why can't they produce it and sell it?

A. Commercially they have produced it and sold it, and they have made hundreds of thousands and millions of lamps, but the process is a very slow one and the filament is essentially used for small types of lamps, coiled filament lamps, such as flashlight lamps and Christmas tree lamps.

Q. 280. Why isn't the trade using it if it is a better filament?

A. It cannot produce it as cheaply as the improved Pacz filament.

Q. 281. I see. That is a very good answer. Now will you tell me this—what method do you use in making your wire—do you use the Coolidge patent, the Pacz method improved, the Schaller method or some method of your own?

A. We use the Coolidge method and add to that Coolidge method certain teachings of Schaller as to heat treatment.

Q. 282. Now, you use the Coolidge method right through until you get your wire. Now you tell me what methods of Schaller you use in your wire that you produce under the Coolidge patent. Am I asking a secret?

Mr. Darby: I don't know.

Q. 283. If that is a secret, you say so.

A. We do not like to disclose any details of the method, but in general, in the wire-drawing operation we subject the wire to a certain heat treatment embodying the teach-
[fol. 293] ings of Schaller and producing larger grains.

Q. 284. Now, if you embody the teachings of Schaller, are they teachings that you got from his patent?

A. Yes.

Q. 285. Well, that cannot be a secret, can it?

A. But there are certain specific steps.

Q. 286. Then you do not adhere to the Schaller patent alone, you use something of your own?

A. We follow the teachings of Schaller.

Q. 287. You don't follow them literally, you change them a little bit, because if you did not it would not be any secret.

A. There are improvements of our own we add.

Q. 288. Which you do not care to disclose at this time?

A. That is correct.

Q. 289. But you do not use any of the Pacz method at all as disclosed in his patent?

A. We do not use any of the Pacz ingredient in the filament supplied to the defendant, nor do we use any of his method. There are two methods, this Pacz——

The Court: I do not intend to take this questioning away from you, Mr. Darby. You may proceed.

Mr. Darby: Very well, your Honor.

By Mr. Darby:

Q. 291. Will you take the disclosure of the Pacz patent and what it tells you to do after the lamp manufacturer has put it in the lamp, in the form of a filament?

A. The lamp manufacturer then takes this fine grain [fol. 294] fibrous tungsten wire and coils it, probably according to standard methods, and puts these coils into the lamps, and according to the Pacz method, those lamps are to be flashed at 30 volts for two minutes, and then at steps of five volts each for two minutes, up to 60 volts, and after this the wire is to be run at 115 per cent. at a standard voltage for 15 minutes. That schedule practically takes 30 minutes. This, however, is not the present practice in lamp manufacture, nor is it the present practice when using the improved type 218 filament.

The Court: I don't think we have to waste much time on that because Dr. Jeffries said they did not do it that way—do you remember that, Mr. Darby?

Mr. Darby: I certainly do.

Q. 292. Now, what difference, in effect, if any, on the non-sagging and non-offsetting properties of the filament would these two different methods of treatment have?

A. I have treated the same Pacz filament, one at 30 volts and the other by quick flashing. When treating at 30 volts I find the structure produced in many instances is a coarse grained structure—large grains.

After burning, these grains continue to grow, and because of that continuance in growth of grains there is also a continuous drooping or sagging of the filament.

On the other hand, I have also taken that same filament and flashed it quickly at a high temperature and caused a coalescence of individual fine grains very quickly, into a [fol. 295] large crystal, and that large crystal assumed almost a permanent structure and would not droop any more, and then the filament would practically be non-sag.

In other words, the characteristic of that lamp as to sagging was far better, as of the second lamp, which was subjected to a quick flash.

Q. 293. The quick flash lamp has better non-sag characteristics than the long flash treatment, is that right?
A. That is provided the original structure——

The Court: Is the same?
The Witness: Is the same.
The Court: We will take that into consideration. Now, will you take him through that second process?
Mr. Darby: I am going right to it.

Q. 294. Now, you have covered one process of the patent. Will you cover the alternative or modified process of the Pacz patent?

The Court: The same as you did during my questioning. You can do that generally. He knows now what we want.
Mr. Darby: All right.

A. Pacz takes the "A" metal which he produces, and which he worked on, and instead of working that down, he takes that powder, and he adds——

The Court: That is, he gets the "A" and "B" solution together, and gets the "A" metal?
[fol. 296] The Witness: Yes, he has the "A" metal and he has the "A" oxide, which he reduces to get the "A" metal, and instead of reducing all of that oxide, he gets that "A" metal and he adds to it some of that "A" oxide, so it is in the proportion of 50 per cent. "A" metal and 50 per cent. oxide. And this is tumbled and sieved, and is reduced, and he calls that "B" metal. And this "B" metal is then worked into wire exactly the same as originally. In other words, the only difference is that in one case he produces the metal direct from the oxide, in the other case he adds oxide to it again and reduces it the second time.
The Court: Is that second process covered by the Coolidge process at all?
The Witness: That second process is not covered by the Coolidge patent, but it is a process that we employ in practicing the Coolidge patent, in that we reduce the Coolidge method in two steps, as I described it before, thereby doing almost the same thing——
The Court: In the patent?
The Witness: In principle it is the same, and we have been doing that in the art, reducing tungsten metal.

By the Court:

Q. 295. What you are trying to tell me is that that second process was practiced in the art for many years by independent lamp manufacturers?

A. In principle.

[fol. 297] Q. 296. Did you use that process before the Pacz patent was ever filed?

A. We used the two-stage reduction process.

Q. 297. He describes before.

A. Before—not exactly as he describes it, but in principle.

Q. 298. Gave you non-sag and non-offsetting filaments?

A. Produced by the Coolidge method, and in following that method secured the production of commercially non-sag filament.

Q. 299. You never applied for a patent for that, did you?

A. It is self-evident, there was no need for applying for a patent for that. That was general practice.

By Mr. Darby:

Q. 300. I would like to take you directly to the limited subject matter of the various patents with which we are concerned in this suit, namely, the production of a non-sag, non-offsetting filament in an incandescent lamp. Now, what, having in mind that the use of the tungsten filaments in lamps preceded the date of the Pacz patent by many years, what does the Pacz patent state produces a non-sag, non-offsetting filament? What thing?

A. He says that the process of producing non-sagging, non-offsetting filament, which includes precipitates of tungsten compound through solution containing as constituents potassium and silica oxide, reducing the precipitate substantially to tungsten, forming an ingot therefrom and working the same into a filament.

Mr. Clark: Where were you reading from?

[fol. 298] The Witness: That is claim 22 of page 4 in the Pacz patent.

Q. 301. To get at it in a different way, does the Pacz patent state that he deliberately adds an ingredient to the material of which the filament is made at some time during its fabrication for the specific purpose of preventing sagging and offsetting?

A. Pacz does not add a specific ingredient to the oxide, but he states that he precipitates the oxide and the beneficial addition together.

Q. 302. In other words, Pacz adds a beneficial addition for the purpose of preventing sagging and offsetting?

A. That is correct.

Q. 303. What is it that he adds as the beneficial addition for that purpose?

A. Silica, an alkaline silicate.

Q. 304. An alkaline silicate?

A. Yes, that is correct.

Q. 305. Did Coolidge in his Battersea process add an alkaline silicate?

A. He did not actually add an alkaline silicate except to a small extent in that some of the alkali from the crucible and some of the silica from the crucible was introduced into the oxide, but indirectly he added alkali silicate in that the precipitated oxide made from alkaline tungstates still contained some alkalis, and that silica that was distilled into the mass produced, with those alkalis, alkali silicates.

Q. 306. Then was there or was there not, irrespective of the source, an alkaline silicate in the Coolidge filament made [fol. 299] under the Coolidge patent, the Battersea crucible method?

A. There was.

Q. 307. If alkaline silicates, when used in the formation of a filament for an incandescent lamp in accordance with Pacz, would prevent offsetting and sagging, would those same ingredients in the Coolidge filament work the same way to prevent offsetting and sagging?

A. They would have that function. And they would have that effect to the same extent provided they are present to the same extent.

Q. 309. To what do you attribute the fact that Coolidge —that is, lamps made under the Coolidge Battersea process here in evidence, have not sagged in their lifetime?

A. Because they had these beneficial additions which in part consisted of silica and alkalis and produced alkaline silicates in the tungsten.

Q. 310. Then in what respect do you consider the Pacz disclosure of the patent in suit differs from the disclosure of the Coolidge patent?

A. Merely in the method of introducing the alkaline silicate into the tungsten.

Q. 311. With respect to the product produced, that is, the incandescent lamp, what difference exists in lamps made under the Pacz patent in suit and lamps made from filaments made under the Battersea process of the Coolidge patent?

A. I have made filaments for both products and both produced a coarse grained structure, and produced a substantially non-sag filament.

By the Court:

Q. 313. You have read that earlier Pacz patent?

A. I have.

[fol. 300] Q. 314. You have read the latter one?

A. I have.

Q. 315. What is the difference between them, if any?

A. The main difference is that in the latter Pacz patent they add silicic acid to the fusion. And in the prior Pacz patent they don't add any silicic acid. That is substantially the only difference.

By Mr. Darby:

Q. 318. As far as the product produced is concerned, what is the difference between the disclosure of the first Pacz patent and that of the patent in suit?

A. Well, the product of this invention refers to the production of pure tungsten filament which is non-offsetting and non-sagging, very similar to the later Pacz patent.

Q. 319. Accepting the description of the product produced as contained in the first Pacz patent, how does it differ from the product claimed by the second Pacz patent?

A. The product claimed is substantially the same.

Q. 320. That is, the claims of the patent in suit, the product claims of the patent in suit find or do not find response in the product described in the first Pacz patent?

A. They do.

By the Court:

Q. 323. Well, the product you get out of both of these Pacz patents is substantially similar and the same, is that right?

A. Yes, but greater care must be taken.

Q. 324. With which one?

A. With the first one. And the percentage of good, non-sag filament produced is not as great as in the second process.

[fol. 301] By Mr. Darby:

Q. 325. I want you to compare now the good grade of filament produced in accordance with the first process, with that produced strictly in accordance with the patent in suit. First, let me ask you if you have made filaments strictly in accordance with the process defined in the first Pacz patent?

A. I have made some some time ago.

Q. 326. Did you compare it as to its non-sagging and non-offsetting properties with the filament that you have made strictly in accordance with the process of the Pacz patent in suit?

A. I did not at that time.

Q. 327. Can you now?

A. I can now, in that the product as to purity and as to structure is very much the same.

Q. 328. How about as to its sagging and offsetting properties?

A. Consequently, as to its sagging and offsetting properties, it is also similar.

Q. 329. You have made reference, frequent reference to the single crystal Schaller-Pintsch filament. Included among the patents of the prior art which are in evidence in the folder, Defendants' Exhibit CCC, are two Schaller patents. Are they the patents respectively for the process of producing the single crystal filament and the product produced thereby?

A. Yes, sir.

Q. 330. Now, with respect to the property of non-sagging and non-offsetting, as contained in the product, namely, the incandescent lamp itself, is there stated in the Pacz patent in suit anything by which the product of the patent in suit, [fol. 302] as defined in the three product claims involved in the suit, can be distinguished from the product obtained and described in the first and earlier patent?

A. There is not.

Q. 331. I ask you the same question with respect to those products described and defined by the three product claims

of the Pacz patent in suit, is there anything contained in the Pacz patent in suit which defines or distinguishes that product from the product obtained from the Coolidge Battersea, that is, the product employing the Coolidge Battersea filament?

A. There is not—under certain conditions.

Q. 332. What do you mean by "under certain conditions"?

A. Well, under most—provided the tungsten oxide started with has been precipitated from alkaline tungstate.

Q. 333. And how about where the beneficial ingredient has been obtained directly from the Hessian crucible?

A. In all cases—the Battersea process does incorporate beneficial ingredients from the Hessian crucible into the oxide.

Dr. Jeffries has testified that the statement contained on page 1 of the specification of the Pacz patent in suit, from lines 48 to 53 and from lines 60 to 66, inclusive, distinguishes the product obtained from the Pacz patent in suit from that obtained from the first Pacz patent. I disagree with Dr. Jeffries in that respect.

I have here four lamps produced from the type of Schaller filament introduced in evidence here, coiled into the shape of a filament and made into 40 volt lamps operating substantially at the efficiency that a tungsten filament of this size would operate normally and I have burned these [fol. 303] lamps four or five hours. These filaments show no sag. Three of these lamps are made with the Schaller filament as received from the Pintsch factory and the fourth lamp is made from the Schaller filament drawn to a smaller diameter and is therefore a drawn Schaller wire, which also shows no sag.

Mr. Darby: I offer the first three lamps referred to by the witness in evidence.

(Marked Defendants' Exhibits DDD, EEE and FFF in evidence.)

Mr. Darby: I also offer in evidence the fourth lamp referred to by the witness.

(Marked Defendants' Exhibit GGG in evidence.)

Q. 339. In the prior art references, can you point to any instance where there has been a deliberate addition of an

alkaline silicate in the production of a filament for incandescent lamps?

A. United States Patent No. 1,045,557 of July, 1914, to Alexander Scoular describe the addition of an alkaline silicate to tungsten.

On page 1, line 39, states:

"According to this invention the tungsten powder is mixed with a small proportion of sodium silicate solution preferably in the thick gelatinous or viscous form."

Q. 340. Now, Mr. Laise, will you refer to any instance on the prior art where the addition of an alkaline borate has been made?

[fol. 304] The Court: Point it out, Mr. Darby. You can read it right into the record. It is an exhibit that is in evidence.

Mr. Darby: It is in the Kruger patent, No. 1,154,701, wherein reference to the addition of boric acid is mentioned at page 1, line 30, and elsewhere, in the process of producing tungsten filaments for incandescent lamps.

The Court: Very well.

Mr. Darby: That is all. You may inquire, Mr. Clark.

Cross-examination.

By Mr. Clark:

X Q. 342. It is true, is it not, that the Coolidge patent does not mention the problem of sagging?

A. The patent only mentions the problem of offsetting which goes hand in hand with sagging.

X Q. 343. Then, the answer to my question is that this Coolidge patent does not mention the problem of sagging, is that correct?

A. Not directly, but indirectly. It refers to an improved filament.

X Q. 344. Just give me the page and line where it mentions sagging or non-sagging?

A. It says: "Such additions, particularly in the case of a filamentary body may be actually produced and a certain amount of ductility and flexibility in a sintered filament, without mechanical workings"—in other words, the additions do add to the flexibility of the filament which in

part also determines the sagging, and to which Coolidge at that time sagging was not so much of a problem.

X Q. 345. And the thing he was interested in, so far as [fol. 305] grain structure was concerned, was in preventing offsetting, wasn't it?

A. He was interested in preventing offsetting, but also in producing a filament which would not droop.

X Q. 346. You have said there is no specific reference to that—drooping?

A. I believe so.

X Q. 347. But at page 2, beginning at line 13, for example, he says, "When this crystallization becomes excessive, crystals may, in the case of a filament, become so large as to extend across the entire section of the filament, and thereupon the sections may move laterally upon each other and produce a condition known as offsetting. I shall hereinafter describe more in detail the special method which I employ for minimizing the loss in ductility and for preventing this offsetting effect."

That is what he was directing his attention to in regard to the size of the crystals, wasn't he?

A. Yes, sir, in part.

X Q. 348. And with respect to the addition to the Battersea crucible method, he points out that you may need to repeat the firing more than once, in order to get enough alumina and silicate into the product to prevent offsetting, is that correct?

A. He does mention that, yes, sir.

X Q. 349. That is; if he does not get enough of these additions of alumina and silica from the Battersea crucible, he is apt to get the offsetting that he wants to avoid?

A. He does not get the beneficial structure that he strived to get.

X Q. 350. But the thing he was striving to get was to get a beneficial structure which would not offset, and if he did not get enough additions from the Battersea crucible, then [fol. 306] he said in efiect you would offset, so you must refire so as to get more of those additions?

A. Exactly the same thing as Dr. Jeffries said I will say in reference to the Pacz patent, he analyzed——

X Q. 351. Never mind that now.

A. The answer is that is correct.

X Q. 352. You do not find anywhere in the Coolidge pat-

ent any suggestion that alkaline silicates are added to the material, do you?

A. Not directly as such, no, sir.

X Q. 353. You cannot point to any part in the Coolidge patent that indicates that alkaline silicates are to be added?

A. Not as such.

X Q. 354. And these additions that Coolidge added, either by the thoria method or by the Battersea crucible method were for the purpose of preventing coarse crystallization of the tungsten at a high temperature, were they not?

A. That only was true in the thoria. They were to prevent offsetting and improve the quality of the filament.

X Q. 355. And that was certainly true of the thoria?

A. That was true of the thoria particularly.

X Q. 356. And you don't find any suggestion in the patent, do you, that the purpose of Battersea method was any different than the purpose of the thoria method?

A. But it proved to be different in actual use.

X Q. 357. Because the people who were attempting to use the Battersea method found it rather uncontrollable, so that they went to the thoria method, isn't that so?

A. Only in part, for certain types of lamps.

X Q. 358. That was so with respect to the large manu- [fol. 307] facture of certain types of lamps?

A. That was so with respect to the manufacture of straight filament lamps.

X Q. 359. You spoke in one of your answers on direct examination of the wire that you furnished to the defendant. I think you said with respect to the wire furnished to the defendant, you did not use anything that is disclosed in the Pacz patent, is that correct?

A. That is true—we did not follow the teachings of Pacz.

X Q. 360. I notice in one of your catalogues that you make and sell both wire which you designate as a non-sag wire and a wire which you do not so designate, is that correct?

A. That is true.

X Q. 361. And which of these wires were you speaking of when you said the wire furnished to the defendant?

A. I have been talking of a wire that we developed during the past year, and it is not illustrated in the catalogue.

X Q. 362. And that is a wire that you furnished defendants and that wire is not illustrated in your catalogue?

A. That is so.

X Q. 363. That is the wire that you say is made by a secret process?

A. By a special process, not using any of the teachings of patents.

X Q. 364. Of course, we are interested here in a wire which you furnished to the defendant prior to the filing of the bill of complaint. What was that wire?

A. The portion that I furnished was comparatively little and that was produced without the addition of alkaline silicate.

X Q. 365. Was it what you then called a non-sag wire?

A. That is true.

X Q. 366. But you are no longer furnishing that wire to the defendants?

A. Not that kind of wire.

[fol. 308] X Q. 367. In this Scoular patent, the material to which you refer as being added, was added as a binder in a squirted filament, wasn't it?

A. That was added as a binder, but it would naturally have certain effect on the tungsten.

X Q. 368. No mention in the Scoular patent of anything about non-sag?

A. I don't believe so. It merely illustrates the use of potassium silicate with tungsten.

X Q. 369. With respect to non-sagging, you know now, don't you, that a prerequisite of non-sag wire is a wire with coarse long crystals, having what you call interlocking boundaries?

A. That is the most desirable structure.

X Q. 370. In Exhibit K, which purports to show photomicrographs of the Coolidge filament, I understand that all of those filaments and all of those photomicrographs were made simply for the purpose of this suit?

A. Yes, sir.

X Q. 371. Made recently?

A. I have made many before.

X Q. 372. I mean the one depicted in Exhibit K?

A. Yes, sir.

X Q. 375. How much did you personally have to do with the manufacture of this thing?

A. I supervised it from the beginning to the end.

X Q. 374. And I notice that some of the photomicrographs seems to be on a larger scale than the others. I do not know that that is of any importance, but I think we had

better have it clear on the record. For example, in Exhibit K, the two photomicrographs in the middle column seem to be of larger size than those in the outside column?

A. When you have a round wire, when you take a section [fol. 309] of it, the diameter increases. This was probably taken a little further down. Or a deeper section than the other, so that explains it. They are all on the same scale.

X Q. 377. With reference to this lamp, Exhibit Z, I have testified that it had been burned 100 hours. I burned it 100 hours and then took it home.

X Q. 379. You mean you timed it?

A. And I had a tag on the lamp stating that "I took it out of my trunk which had been in storage a considerable time, stating that it had burned 100 hours, and then it broke."

X Q. 380. It broke after you took it out of your trunk?

A. Yes, it was broken by handling.

X Q. 381. That is, so far as you now know, all you know is that you found this in your trunk and it had a tag on it indicating that it had been burned a hundred hours?

A. Yes, sir.

Mr. Clark: That is all.

Redirect examination.

By Mr. Darby:

R. D. Q. 382. Just one question. In view of the fact that the cross examination has developed that you have changed your process of producing wire that you sell to the defendant Wabash, it makes it necessary for me to ask about the wire prior to your present process, the wire you sold the defendant Wabash prior to the process under which you are manufacturing the wire that you now sell them. Did you use an alkaline silicate?

A. Not an alkaline silicate.

R. D. Q. 383. In that wire, did you use a boron compound?

[fol. 310] A. There was a boron compound, yes, sir.

R. D. Q. 384. So with respect to the non-presence of alkaline silicate and the actual presence of a boron compound, your product today is the same as it has always been with respect to the sales to this defendant of the non-sagging filament?

A. That is right.

Recross-examination.

By Mr. Clark:

R. X Q. 385. But the lamps which you produce here, as I think they were, PP, QQ, RR, as having been made from the filament which you are furnishing to the Wabash Company, they were made of the filament that you are now furnishing them?

A. That is correct.

(Witness excused.)

Mr. Darby: I offer in evidence these various lamps that have been marked for identification but have not been offered in evidence.

I offer in evidence Defendants' Exhibit D for identification.

(Marked Defendants' Exhibit D in evidence.)

Mr. Darby: I offer Defendants' Exhibit F for identification in evidence.

(Marked Defendants' Exhibit F in evidence.)

Mr. Darby: I offer Defendants' Exhibit G for identification in evidence.

(Marked Defendants' Exhibit G in evidence.)

[fol. 311] Mr. Darby: And E for identification in evidence.

(Marked Defendants' Exhibit E in evidence.)

Mr. Darby: I offer in evidence an article in German published in the Die Welt der Technik, Berlin, April 1, 1913, with the translation.

(Marked Defendants' Exhibit HHH in evidence.)

Mr. Darby: There is an article entitled the Osram Metal Filament Lamp, and I call your Honor's attention particularly to the microphotographs of the filament as shown on page 131 as to the grain structure.

Defendant rests.

The Court: We will take a recess until Friday morning at ten a. m.

(Adjourned to Friday, July 3, 1936, at ten o'clock a. m.)

Brooklyn, N. Y., July 3, 1936.

Met pursuant to adjournment at 10:00 a. m.; present as before.

ZAY JEFFRIES, resumed the stand, in rebuttal, and further testified as follows:

Direct examination.

By Mr. Clark:

Q. 463. Dr. Jeffries, I call your attention to Defendants' Exhibit N, which is a microphotograph of a coiled filament [fol. 312] introduced by the witness Cowles, and asserted to be a filament made by the Westinghouse Company at a certain date. Will you please compare the filament shown in that Exhibit N with the Pacz filament?

A. The photograph shown in Exhibit N appears to be a coil, containing about nine turns. One side of the photograph shows the turns which Mr. Cowles said were in focus and the other side out of focus. The lighter side is the side which is supposed to be in focus and the side showing the dark sections of coils were supposed to be not in good focus. The part in good focus was described, I believe, as being typical of the coarse grained structure. As a matter of fact, it is typical of a fine grained structure and the other side, whether in focus or not, is more typical of a coarse grained structure. The part that is in focus is typical of a fine grained structure. That would be a sagging filament because of its fine grained structure.

Referring as a whole to Defendants' Exhibits O, O-1 and O-3, which were produced by the same witness, Mr. Cowles, and each of which contains on the back notations Ca, for calcium, 100 mils., and trans., transverse. These are not representative of coarse grained so-called interlocking grain structures. They are representative of sections of metal with a number of grains across the entire section. Tungsten filament material having such a structure would not be a non-sag, non-offsetting structure.

Referring to Exhibit O-2, which says on the back "Ingot 501 Section Transverse 200 mils. diameters." That appears to be a typical micrograph of a tungsten ingot structure. This particular ingot happens to be fairly coarse [fol. 313] grained as indicated by the magnification shown

on the back of the microphotograph mounting. It was supposed to be 200 magnifications. The structure of the ingot has little relation to the structure in the finished filament. This is a structure before any mechanical working. It cannot be said that this structure is typical of a non-sag, non-offsetting structure.

Referring to Exhibits P, P-1, P-2, and P-3, inclusive. First I note that Exhibits P and P-1 are duplicates of each other, and P-2 and P-3 are duplicates of each other. So we really have only two exhibits to consider. These are also typical structures of the ingots, and therefore, nothing can be predicted as to the non-sagging or non-offsetting nature of a filament which might be produced from an ingot with such a structure.

Next I should like to call attention to Exhibit Q, which was offered as a microphotograph of a Pacz 218 filament. That is not a representation of a Pacz 218 filament.

Referring to Defendants' Exhibit J. This is an exhibit which was shown to me during the prima facie case, without my having been given any information as to what it purported to be. And at page 201 of the record, in my answer to a question directed to this exhibit I said, "Again I wish to say that I do not know anything about the previous heating and mechanical treatment of the material from which that microphotograph was taken." I now know from the evidence subsequently introduced by the defendant that this Exhibit J shows a filament which has been burned 500 hours and which is alleged to have been made under the Battersea process. With that information in mind I can [fol. 314] say definitely that it is a sagging filament. The structure after the 500 hours indicates that the grains are not very coarse and especially they are not long grains.

The laws of grain growth are such that there have never been any fewer grains in any part of the preceding 500 hours of burning than obtain in the structure as shown. Therefore, the tendency has been for the grain size to be finer than it is after the 500 hours. So I have no hesitancy in saying that that is a sagging filament.

At page 351 of the record, Mr. Laise, in testifying with regard to a certain lamp, Exhibit Z, said that that lamp was produced in 1916, and that at that time "We fired the filament in a silica tube and added lime to the filament." And he said further, "This particular lamp had lime silica

and alkaline silicates added to it." Then, the following question, "That is added to it in addition to what it got from firing in the crucible? A. The alkaline silicate was developed during the firing operation." The alkaline silicates would not be developed during this firing operation in a silica tube, where lime was added. The assumption is, I think, that the lime silicate would be regarded as an alkaline silicate, and I would not regard lime silicate or calcium silicate as an aklaline silicate.

Exhibit K is a chart of microphotographs of Coolidge filament. Three of the sets of microphotographs represent in my opinion normal reproductions of the Coolidge teaching. The thoriated one on the right is typical of the Coolidge thoriated filament. The Battersea lot N-971 is typical, but rather too coarse a grain, especially in the condition [fol. 315] "as shipped." Battersea lot N-991 is also typical of the Coolidge Battersea product.

There is an inconsistency in the results on this lot of metal, however. Between the structure shown in the filament "as shipped" and after burning 100 hours on the one hand, and the sagging results reported on the heavy filament on the other hand, there is an inconsistency. The sagging result is indicated as "2," which I take to be two millimeters sag. It is indicated that that sagging result is made on a filament of heavy section; therefore, not the hundred watt filament which is depicted in the two microphotographs in the column, second to the right.

The filament with the structure shown in the "as shipped" condition in this lot N-991, and having structure shown as burned over 100 hours in the same column, is a decidedly sagging filament. The grain size in the "as shipped" condition is relatively small, and it is still a sagging structure after burning over 100 hours. This may indicate merely the non-uniformities encountered in the Battersea process where the heavy filament showed little sag but where the hundred watt filament showed decided sag, or at least the structure is definitely a sagging structure. A sagging structure because of the fine grain.

On the other hand, I may say that offsetting could not occur in either of the structures shown in the Battersea lot N-971 or lot N-991. So that to that extent those lots represent filaments having a quality that Coolidge was after,—a non-offsetting filament.

Now, with respect to the Battersea lot N-989, I may say [fol. 316] that that is the result which Coolidge teaches with reference to the structure of the Battersea filament.

In the first place, the filament as shipped is coarse grained. That indicates that the coarse grained structure has been developed very promptly during the early stages of the burning. Also the filament shows that it is coarse grained after burning over 100 hours, as one would expect if it is coarse grained after the flash ageing. I would say that if this filament has been made strictly in accordance with the Coolidge process, namely the Battersea process, and it has a structure as shown in the charts now marked— or in the micrographs now marked A and B, that offsetting structures should be found at some points along the lengths of an entire filament. If such structures cannot be found then I should say that the product is not a Coolidge product.

In trying to depict the properties of the filament throughout its length, from a short section, such as is shown in micrographs A and B, in the chart of Defendants' Exhibit K, I should merely like to point out what could be produced in a short section from a filament known to be offsetting. If one would polish and etch, for example, a section like that shown in Plaintiff's Exhibit 12, a short section could be found, for example, the section in the middle of the filament as pictured in Plaintiff's Exhibit 12, which would show crystals extending across the entire section, but which would not show offsetting. On the other hand the filament as actually seen shows offsetting on approximately five planes, but even with bad offsetting, such as is shown in [fol. 317] Plaintiff's Exhibit 12, short sections of the filament can be picked out which show no offsetting.

With regard to my experience with the Battesea method of making the Coolidge filament and referring to this Exhibit K, I should say that the Battersea lot N-991 is fairly representative. The Battersea lot N-971 is not hardly good enough and the Battersea lot N-989 would be a reject lot under the Coolidge process. This Battersea filament, if, due to irregularities of production, it has a large grain it is then an offsetting filament, and if it is a non-offsetting filament it is a sagging filament because it has fine grains.

Defendant's Exhibit T is a chart of microphotographs supposed to represent filaments made according to the Pacz patent in suit. None of those filaments represents the Pacz

structure. None of them would give a commercial non-sag filament.

Defendant's Exhibit U is a chart of microphotographs of various filament materials. The vertical columns on the left represent the unburned condition and the vertical column on the right represents two and one-half hours of burning. The top set is supposed to be a Coolidge thoriated tungsten set. That is normal for the Coolidge product.

The bottom set is the Schaller material. That is normal for the Schaller material.

The second from the top is supposed to be the Coolidge Battersea, and that is abnormal. That is, if a typical Battersea filament is burned two and one-half hours it should not have the coarse grained structure shown in this exhibit. [fol. 318] Unless a fine grained structure is produced the teachings of the Coolidge patent have not been complied with.

The set of filaments in the horizontal row next to the bottom represent supposedly the Pacz tungsten filament made according to the Pacz patent in suit. These are also abnormal and the product depicted in these micrographs is not the Pacz product.

In carrying out the Pacz process according to the patent, the degree of washing that is done affects the final result. I should say that the most probable place where the process has fallen down is in the washing, and that this is typical of a structure of a filament which has been made from oxide which has been washed so much that too much of the Pacz additional material has been washed out. It does not produce a structure as taught in the Pacz patent.

Q. 488a. I am now going to refer you to Exhibit V.

Mr. Clark: Mr. Darby, during Mr. Laise's examination with regard to this exhibit, no reference was made to the bottom photograph, and you offered the chart in evidence. In your offer only the photomicrographs were offered. So I suggest we remove that bottom photograph from the exhibit.

Mr. Darby: Oh, no, leave it in.

Mr. Clark: It has not been referred to or identified, and when you offered it, you offered only the photomicrographs.

Mr. Darby: I can call him back and have him refer to it [fol. 319] and identify it as just exactly what this label says it is. It is illustrative——

Mr. Clark: Then, do that.

The Court: Suppose we stipulate that if Mr. Laise were called, he would testify that is the average sag of the lamp? After all, I have seen the lamp——

Mr. Clark: As now produced.

The Court: As now produced.

Mr. Darby: And illustrates average sag.

Mr. Clark: As now produced by the Wabash Company using filament furnished by Mr. Laise of Callite.

Mr. Darby: That is right.

The Court: I have seen them, Mr. Clark. To my mind that is better evidence than anything he can produce.

Mr. Clark: From what you have seen of the lamps?

The Court: Yes.

By Mr. Clark:

Q. 489. Will you please comment upon this Exhibit V, and in so doing compare what is shown there with what is shown in Plaintiff's Exhibit 30?

The Court: As you testify, refer to the pages, will you, in Exhibit 30?

The Witness: Yes.

A. First I should like to say that the micrographs of filaments shown on Defendants' chart, Exhibit V, are not the Pacz structures. Assuming that these filaments have [fol. 320] burned at normal voltage 800 hours, as indicated on the chart, and assuming that the small length shown in the micro-section at the bottom left of the chart is representative of the structure of the filament throughout its length in the hot portion, that is definitely not a Pacz portion. It is a filament which will not offset, however, but it will sag.

Furthermore, this structure as shown in Defendants' Exhibit V is an entirely different structure from that shown in Plaintiff's Exhibit 30, which shows a number of structures of filaments taken from some of defendants' lamps purchased some time ago.

Comparing, for example, the micro-structure of the filament shown in Defendants' Exhibit V with that of the one shown on page 2 of Plaintiff's Exhibit 30, it can be seen that the latter has crystals extending across the entire diameter of the filament, and therefore, in order to avoid

offsetting, the boundaries between crystals must be of such nature that side-slipping or offsetting will not occur.

The nature of the boundaries shown on page 2 of Plaintiff's Exhibit 30 is such that offsetting cannot occur on that section.

The grains are large as taught by Pacz, so there will be no sagging. Not only large in diameter, but they are relatively long.

The same comment may be made with reference to the micrographs on page 3 of Plaintiff's Exhibit 30, also on page 4, and page 6, and page 7, page 8, page 9, page 13, and page 14.

The one on page 15, was in the unheated state, in the fibrous form.

The same comparison can be made with reference to a part of the micrograph on page 16, particularly the lower [fol. 321] half of the filament. The same comparison holds with reference to page 17, page 18, page 19, page 20, page 21, and that is all of the micrographs in Plaintiff's Exhibit 30 to be compared with Defendants' Exhibit V.

I can say definitely that the two filaments are not the same kind of filaments. The filaments shown in Plaintiff's Exhibit 30 are of the character that would produce a non-sagging, non-offsetting filament, whereas those in Exhibit V are of the character to produce a sagging filament.

Defendants' Exhibit I is a chart of micrographs supposedly representing Pacz filament and made in accordance with the Pacz patent in suit, and filament made from boric-acid-doped tungsten oxide, which was disclaimed in the Pacz patent in suit. The representation of the structure produced supposedly in accordance with the Pacz patent in suit is a very poor reproduction of the Pacz product. It is not representative of the Pacz product, although it is obvious that the product has some of the characteristics of the Pacz product.

It was probably overwashed. That would be my guess as to the reason that this product has not responded as a Pacz filament should to the grain growth on the heating of the filament.

Now, with reference to the boric acid doped structure, that is in general similar to the structure which I have reproduced by following the same method, although this

structure is somewhat coarser than the one I produced. It is of the same nature. One of the characteristics which I found in connection with this product was that it was extremely brittle when cold.

[fol. 322] On the other hand, it did sag in the bottle test at 100 milligram size. This filament is a smaller size than the one which I produced, but the structure in general is of the same nature as that which I produced. I do not consider that a Pacz structure and I do not consider the result indicated by the micrographs as a Pacz achievement.

Referring to Defendant's Exhibit XX which is supposed to depict a filament resulting from the use of the Scoular patent No. 1,104,557. As I remember the testimony about this exhibit it was that the filament had been made by the drawn filament method rather than by the squirted filament method as disclosed in the Scoular patent. There is nothing in that patent that would lead one to use an alkaline silicate in the manufacture of a drawn filament. The Scoular patent refers only to the manufacture of squirted filaments. The sodium silicate called for in the Scoular patent, is used as a binder for the purposes of making a paste with tungsten powder. In the manufacture of squirted filaments it is necessary, at one stage, to make a paste which can be squirted. In the prior art, carbonaceous pastes had been used very generally. The Scoular patent is one for another method of making a squirted filament by using another material, which was sodium silicate, to develop the paste. The sodium silicate is also known as water glass. It is the same material used for treating eggs for cold storage, and therefore, it is a material which can be used for purposes of making a paste. There is nothing in the Scoular patent which would indicate that the sodium silicate had any effect [fol. 323] whatsoever on the sagging character of the filament, and the patent teaches nothing with respect to the sag problem.

I have myself produced a squirted filament in accordance with the disclosure of the Scoular patent. The filament was fine grained and it sagged very badly. Incidentally it was also very brittle.

I produce herewith a microphotograph magnified 200 diameters of the Scoular squirted filament produced in accordance with the Scoular patent.

Mr. Clark: I offer it in evidence.

Mr. Darby: Was that after burning or before burning the filament?

The Witness: That was after manufacture of the filament and before burning.

Mr. Clark: I offer it in evidence.

(Marked Plaintiff's Exhibit 33 in evidence.)

The Witness: A sag test was made on this and it sagged badly as would be expected from its grain structure.

Q. 499. During the prima facie case you testified, I think, on two occasions with reference to single crystal filaments, pointing out the impracti-bility of the use of such filaments. Were the filaments to which you then referred, filaments of the character produced by the Schaller patent here?

A. Yes.

Q. 500. Is there any further comment you wish to make upon the Schaller patent?

The Court: He will get a chance to enlarge on that when I question him at the end.

[fol. 324] Mr. Clark: All right, your Honor.

With reference to the Kruger patent, it was pointed out by Mr. Darby and Mr. Laise that this patent showed the addition of an alkaline borate and in reference to it, reference was made to page 1, line 30, where boracic acid is mentioned. Boracic acid is not an alkaline borate. I cannot find an alkaline borate mentioned anywhere in the Kruger patent.

At page 460 of the record, after referring in several previous questions to the same subject matter, Mr. Laise said at Q. 258 as follows:

"Now, do you say that under that patent"—that is the Pacz patent—"it does not tell you how to make this filament," and the answer was, "It does not say anything about the mandrel or how closely it has to be wound or how far apart it has to be wound. It does not go into those details of filament manufacture and that is quite vital." The Pacz patent in suit does give two very specific examples as to distance between turns and the mandrel size.

On page 3 of the Pacz patent in suit, beginning at line 6, it is stated that the 50-watt 115 volt lamps, had a filament of 1.62 mils. in diameter and that the filament was coiled on a

mandrel 5 mils. in diameter and the turns for each originally ran from 421 to 430.

It is also stated at line 116 that the filament of the 100 volt lamp was 2.63 mils. in diameter and was shaped by coiling on an 8 mils. mandrel and the number of turns each per inch originally ran from 257 to 269. That is very specific information on the points mentioned.

Q. 504. What would you say as to the then knowledge [fol. 325] of the art in the coiling of filament, was that information entirely adequate for the lamp manufacture?

A. It was.

At page 462 of the record, questions 270 to 273, Mr. Laise testified as follows:

"Q. Now, you claim that this filament 218 that is in evidence here is an improvement over the one disclosed in the Pacz patent, is that right?

"A. Yes, sir.

"Q. You claim this 218 filament is not the filament that you make if you adhere to the Pacz patent?

"A. That is true.

"Q. And the 218 filament improved is non-sagging and non-offsetting?

"A. It is much more so than the other.

"Q. Then they must do something with that 218 improved filament that is not disclosed in that patent Am I right in concluding that?

"A. Yes."

The Pacz filaments which I examined in 1915 had the same characteristics as the commercial Pacz filament of today. The difference is that there was not as large a percentage of the filaments produced in the earlier days which had the preferred grain structure and, hence, the preferred non-sagging and non-offsetting characteristics which we obtain so regularly and uniformly at the present time.

The improvement has been one of consolidating commercially what Pacz produced as early as the summer of 1915, in accordance with my own knowledge and experience. It is true that the Pacz product of the earlier days was not as uniform as the Pacz product of today. I think I explained that, however, in my prima facie testimony. Such [fol. 326] changes as have been made in the Pacz process

in its commercial manufacture, do not depart in principle from the Pacz process as disclosed in the Pacz patent.

The process as disclosed in the Pacz patent was a process for producing this material by the pound, one might say, and the commercial necessity was one later of being able to produce it by the hundreds of pounds, or even by the ton. When the size of the batch was increased that brought about the necessity for certain changes in connection with the control. Pacz taught that the compounds which he used should be left in part in the oxide. The subsequent work consisted to a large extent in ascertaining how much should be left in the oxide and then putting that under commercial control.

I may say in all cases, the principle outlined by Pacz in his patent in suit is followed in the manufacture of the commercial filaments.

At page 468 of the record, Mr. Laise, testified that a quick flashed lamp had better non-sagging characteristics than a long flashed, than one that had a long flash treatment. That is not true of the Pacz product. The Pacz filament develops a better non-sag and non-offsetting crystal structure if it is given a slow heating the first time it is heated up from the fibrous condition.

With respect to the Pacz and Coolidge patents, Mr. Laise testified at page 463 as follows, in answering a question by the Court, "Now, you tell me whether the Pacz patent insofar as you have interpreted it there is an improvement over the Coolidge patent on non-sag and non-offsetting?

A. I consider it another method of producing the same result."

[fol. 327] I do not agree. I should say that very definitely when one follows the Coolidge teaching he produces a fine-grained filament in order to solve the problem of offsetting. Inevitably such a filament is a sagging filament. If such a filament does not sag, it is because it is coarse-grained, and, therefore, will offset.

Pacz taught the immediate production of coarse crystals and showed a way to produce such a product which would not sag because of the coarse crystals, and would not offset because of the contour of those crystals. So that in that respect the teachings of the two patents are exactly opposite as to sag.

That is reflected in the commercial products produced under Coolidge and produced under Pacz. The commercial product produced under the Coolidge was and is today a fine-grained structure as shown in certain of the exhibits which I put in evidence in prima facie.

For example, Exhibit 16 is typical of the commercial Coolidge product. And also Exhibit 19 at the left is typical of the commercial Coolidge product, and Exhibit 19 at the right is typical of the Pacz product. So that those two structures represent in my opinion the typical teachings of the two patents. The Coolidge patent does not deal at all with the matter of sag or non-sag.

At page 485 of the record Mr. Laise testified, X Q. 354, "And these additions that Coolidge added either by the thorium method or by the Battersea crucible method were for the purpose of preventing coarse crystallization of the tungsten at a high temperature, were they not?

"A. That only was true of the thoria."

[fol. 328] It is very clear in the Coolidge patent itself that the thoria was regarded as an equivalent of the Battersea additions with respect to the effect on the structure of the filament. That is indicated on page 6 of the Coolidge patent, beginning line 118, as follows:

"It may be that offsetting, a phenomenon which, as above explained, is characteristic of some drawn wire lamp filaments, is due to the crystallization of the metal and the segregation of impurities whereby spots are developed, whereby this side-slipping or offsetting occurs and that the producing of the additions introduced through Hession or Battersea crucibles retorts interfered with the diffusion of such impurities, and thus retards crystallization."

The specification continues then to describe the addition of thoria to produce non-offsetting effect, and he refers to thoria then as a direct addition as opposed to the indirect addition of the material of the Battersea crucible incorporated during a firing operation.

Then on line 29, page 7, is found this statement:

"Usually, however, instead of directly adding the substances, I prefer to employ the treatment above described of simply firing the tungstic oxide in a Hessian or Batter-

sea crucible, for this treatment is simple, successful and reliable."

[fol. 329] There he refers to the direct addition on the one hand and Battersea on the other, as being the equivalent.

Then on page 7, line about 48, there is a reference to:

"Omitting the additions, whether produced by the direct introduction of additional material as above described or by the Battersea crucible process."

There is also indicated in claim 14 that the additional materials are considered for the purposes of preventing coarse crystallization of the tungsten at a high temperature. That, as I understand it, covers the addition, whether through the Battersea method or the thoria method.

Q. 515. Now, Dr. Jeffries, will you please compare the subject-matter of the patent claims in suit with the prior art as produced by the defendant here?

Mr. Darby: I don't know whether that is along the lines of your Honor's idea or not.

The Court: He is covering it. Probably I won't have to ask these questions. I will have one question to ask only.

The Witness: May I ask which claims are in suit?

Q. 516. Claims 25, 26 and 27. You might take claim 26, as an example.

A. Claim 26 reads:

"A drawn filament for electric incandescent lamps or [fol. 330] other devices composed substantially of tungsten and made up mainly of a number of comparatively large grains of such size and contour as to prevent substantial sag and offsetting during a normal or commercial useful life for such lamp or other device."

The Court: I think I have got that pretty clear. He has gone all over that.

Mr. Clark: I just wanted him to summarize the comparison between that and the prior art, your Honor.

The Court: Very well.

The Witness: There is no other teaching in the prior art to produce a coarse grain structure in the filament except that found in the Schaller patents.

The Schaller patents deal with both the process for making a single crystal tungsten filament and the product so produced. There are two of the Schaller patents, one is for the process and one is for the product. I mention the Schaller disclosure because they represent the only reference that I know of in the prior art which teaches the production of large crystals.

Now, the Schaller patent No. 1,256,929, which deals with the process of making a single crystal of tungsten states that it is not possible to produce a filament such as Pacz has produced. This statement is found in the Schaller specification at page 1, beginning line 21, wherein he states as follows:

"Since it is not possible to control the ultimate formation of crystals in producing the same, either by the hardening of molten masses or fluxes or by sintering, the crystals [fol. 331] in the final metal body are generally in a disordered state."

Schaller teaches grain growth but he teaches that the grain boundaries must all be eliminated in order to get rid of the alternating current effect which, of course, was the known offsetting effect.

He describes a process whereby the crystal boundaries shall all be eliminated and then in the next Schaller patent he claims that product, a single crystal tungsten filament.

Now, all the rest of the prior art, of which I have knowledge, teaches that the tungsten should be treated so as to retard or inhibit grain growth. It teaches that if grain growth is permitted to occur to such an extent that the crystals extend across the filament, then an offsetting filament will result.

Therefore the patent claim which I read represents the first multi-crystalline filament which is both non-sagging and non-offsetting at the same time. The result is produced by doing exactly the opposite of that which the art taught, namely the production right away of a coarse crystalline filament and the production of a multi-crystalline structure. I distinguish multi-crystalline from Schaller, because Schaller produces a single crystalline structure without the grain boundaries—Pacz produces a structure with grain boundaries and that means that the Pacz filament was composed of a number of grains and such a filament might be referred

to as a multi crystal filament as opposed to the Schaller single crystal filament.

Mr. Clark: That is all.

[fol. 332] Cross-examination.

By Mr. Darby:

X Q. 517. Dr. Jeffries, I would like to start with the subject that was developed in the Coolidge case. What effect has the drawing on the shape of a crystal in the metal prior to drawing, doesn't it elongate the crystals?

A. Yes. Produces eventually the so-called fibre structure.

X Q. 518. Am I correct in understanding that the General Electric Company manufactures its filament under the Pacz process from the raw materials in 100 pound batches in its commercial practice?

A. Batches are probably even larger than that at the present time, and then the batches of metal so produced are mixed in lots of more than a ton.

X Q. 519. What was it in the early days in producing under commercial practice, the Pacz wire?

A. The process was carried on on a very small scale, as indicated by the amounts covered in the Pacz method, described in the patent in suit. And those amounts were commercial amounts.

With reference to the early days in commercial operations under a Pacz patent there was not as large percentage of good sagless filament obtained as there is to-day.

X Q. 522. And yet all these materials were treated the same way, the process was standardized at that time, wasn't it?

A. Yes, it was supposed to be treated the same way.

X Q. 523. In what respect did the wire that was produced that was not good differ from the wire that was produced that was good?

A. In the poor wire the grains were smaller and they were longer in developing when the filament was first heated up.

[fol. 333] X Q. 524. By that you mean that each individual grain was smaller or do you mean there would be some large grains and then some small ones, or just what do you mean by that?

A. In general all the grains would be smaller. Sometimes a filament would be produced with a short section of grains that were relatively small, but in general in the poor wire all of the grains were smaller than in the good wire.

X Q. 525. If we take a section of filament which has a group of small grains, which have not grown, with larger grains on either side of that point where the small grains appeared, what would be the practical result of burning that filament in a lamp, assuming that the portion of the filament that has the small ingrown crystals had been located between two supports?

A. That would depend upon the extent of the small grained region. If the small grained region is very short, the coarse grains on either side act as supports for that very short section, and the filament may be substantially non-sagging, and in the Pacz filament such a structure is non-offsetting. And if it was not very short the result would be sagging at that point.

X Q. 526. And it would tend to offset, wouldn't it?

A. No, not in the Pacz filament. The Pacz filament does not offset, whether it is a fine grained or coarse grained. If it is fine grained, it could not offset any more than the thoriated filament or any other filament; and if it is coarse grained the boundaries are so disposed and of such nature that slipping does not occur.

X Q. 527. What is the total length of wire that is utilized in producing an ordinary commercial coiled wire filament? [fol. 334] A. Of the 110 volt variety, let us say it would average on the order of a foot and a half.

X Q. 528. And in the early days, did the crystalline structure of the Pacz wire that was produced differ throughout that foot and a half length in contour and size of the individual crystals?

A. It differed specifically in that no two grains could be considered to be exactly alike, perhaps or no two contours could be exactly alike, but they all followed the broad principle of largeness as to size and to non-slipping contour.

X Q. 529. In making microphotographs what is the actual length of the filament that is subjected to microscopic examination? That is, its physical length, for example, in Plaintiff's Exhibit 30.

A. On the order of one hundredth to a few hundredths of an inch. That is customary in the practice of making microphotographs.

Of course, in the photograph of the coils, the longer linear length of the filament is included because the coil length then takes the place of the filament length in examining the piece of filament.

X Q. 531. Am I correct, if you take a microphotograph of that small length of a particular filament you would reasonably expect that substantially the same arrangement would exist throughout the entire length of the filament?

A. No, not unless one knew the character of the filament that he was working with.

X Q. 532. Now, I understood you to say that the long flash treatment—that is, the longer period of time flash treatment, is better in producing a Pacz sagless and non-offsetting filament than the short period of time treat-
[fol. 335] ment—is that right; do you say that?

A. No, not exactly. The distinction is this: Mr. Laise said that the so-called flashed structures, that is, the structure produced by heating immediately to a very high temperature, were more non-sag than structures produced by reaching the high temperature through gradual steps or by slow heating. I merely say that in the Pacz filament the non-sag and non-offsetting character is better if the high temperature is reached by slow heating rather than by flashing immediately to such a high temperature.

X Q. 534. And I presume that is the reason why the General Electric Company in its commercial procedure has adopted a total of two minute flash treatments as compared with the 30 minute flash treatment specified in the patent in suit?

A. No, they are both the same kind of a treatment, both reach a high temperature by heating steps from the fibrous structure to the structure produced at the high temperature. The procedure disclosed in the patent in suit would produce even a better structure but the difference in time between 30 minutes and two minutes, now used, does not produce a sufficient difference to warrant the increase in time schedule.

X Q. 535. And how long have you personally, Dr. Jeffries, been familiar with the commercial manufacture of Pacz wire?

A. The commercial manufacture of the ingot itself, since 1917. The commercial manufacture of the wire from the ingot since the summer of 1915.

X Q. 536. I gather from your testimony that you have had considerable experience in the manufacture of the Coolidge filament under the Battersea process?

[fol. 336] A. No, I have not. I have examined the filament, but I have not had experience in the manufacture of such filaments.

X Q. 537. What is the longest Schaller filament, as distinguished from a crystal, that you have seen?

A. I cannot say at the moment, but I have followed one crystal under the microscope for several inches.

X Q. 538. Have you ever seen a filament made of Schaller crystals longer than seven inches?

A. I think so, but I would not be sure.

X Q. 539. In other words, it is not necessary that the entire filament itself be comprised of but a single crystal, is it, under the Schaller process?

A. Yes, it is; so he states.

It is a fact that literally the only difference between claim 26 that I selected as illustrative and claim 25 which is likewise in suit, is that claim 26 defines the filament as a drawn filament, whereas claim 25 describes the filament merely as a filament.

Mr. Darby: That is all.

Redirect examination.

By Mr. Clark:

R. D. Q. 542. I think the first questions that were asked you by Mr. Darby were inquiring as to whether the drawing of a filament elongates the crystal, and you replied that it did, so that it produced a fibrous structure. Now, does that fibrous structure continue to exist after heating?

A. No, that fibrous structure is destroyed by heating at temperatures above say, 1200 or 1400 degrees Centigrade, and always destroyed except where the filament is cooled in the clamps, by heating through filament temperatures. Thereafter recrystallization takes place.

[fol. 337] R. D. Q. 544. And it is that recrystallization following the fibrous state that Coolidge teaches should be retarded so as to produce more crystals?

A. Yes, it is the growth of the grains which develop by

the destruction of this fibrous structure, by heat, which Coolidge teaches should be retarded.

Mr. Clark: That is all.

By Mr. Darby:

Q. 545. You are talking of the Coolidge thoriated tungsten filament?

A. Yes, and also the Coolidge Battersea.

Mr. Darby: That is all.

By the Court:

Q. 546. Now, Doctor, you heard Mr. Laise testify the other day?

A. Yes.

Q. 547. And you heard him testify that the Pacz patent in suit goes to a certain point?

A. Yes.

Q. 548. Then, you proceed under the Coolidge patent?

A. Yes.

Q. 549. Do you agree with that?

A. Yes.

By the Court:

Q. 550. Will you please tell me whether the ingredients that he testified to in the Pacz patent up to that point, whether you use those ingredients?

A. Whether you use them in Pacz?

Q. 551. Yes.

A. Yes, we do use those ingredients.

Q. 552. As he testified, or is there a difference?

[fol. 338] You remember he testified he took certain materials and mixed them up to a certain point in the Pacz patent, and then he says you use the Coolidge method after that?

A. Yes, that is correct.

Q. 553. Do you use the ingredients that he testified to, that is, used under that patent as he interpreted it?

A. Yes, we do.

Q. 554. Now, he testified to a certain process up to that point, is that right?

A. Yes.

Q. 555. That process, as he testified to, is that correct, or is it different?

A. It is correct as he testified to.

Q. 556. Now, under the Coolidge patent, will you indicate to me the difference between the process up to the point in the Pacz patent that you used the Coolidge method, and the Coolidge method up to that point?

A. Yes.

Q. 557. I think you understand what I mean.

A. I think so.

May I first modify the previous answers to make clear what I think is clear from the record earlier, that when I say that we use the same ingredients, I do not mean necessarily that we use the sodium nitrate or potassium carbonate.

Q. 558. You use an ingredient that is similar to it or comparable to it, is that what you mean?

A. That is correct. We use alkaline silicates. In the first place, the ingredients which Coolidge put into his ingot are of the kind which must remain in the ingot after it is sintered, that is, after it is heated to the high temperature and ready to work, in order to produce the effect which Coolidge desires, namely, the retardation of the crystal growth.

The ingredients of the Battersea addition are definitely [fol. 339] described as consisting largely of alumina and silica. That is on page 2.

Q. 559. Of the Coolidge patent?

A. Of the Coolidge patent, lines 81 and 82. Those are the ingredients which one would expect that the oxide would absorb when heated to a high temperature in a Battersea crucible, as stated in my prima facie testimony.

Battersea crucible material is fire clay material, and fire clays are essentially alumina and silica and selected for fire clay or crucible use for the reason that they are low in alkali metal content, and by low I mean under two or three per cent as a rule, and I think the Battersea alkali metal content is around one per cent, and by alkali metal content, I mean potassium oxide and thorium oxide added together. It is obvious therefore that the Coolidge Battersea oxide could not contain very much alkali metal. Although it contains ample silica it could not contain more than a minute amount of alkali silicate.

The alkaline metal could not be incorporated into the Coolidge Battersea in any other way in the Coolidge process, which is described at page 2, beginning line 61 of the Coolidge patent. There it is stated, "Starting with tungstic oxide WO_3"—that is the chemical symbol for tungstic oxide—"as pure as commercially obtainable, I dissolve it in ammonia water and thus form ammonium tungstate, which is purified by crystallization over a steam bath and is then, after washing by distilled water and drying, decomposed by the application of moderate heat, say, 400 to 500 degrees centigrade, which drives off the ammonia and [fol. 340] leaves purified tungstic oxide."

I should call attention to the fact that the stress is put on the purity of the tungstic oxide at that point. He starts with a tungstic oxide as pure as he can obtain it commercially, but he is not satisfied with that, and he purifies it again by dissolving it in ammonia and recrystallizing and washing, and then igniting, so as to drive off the ammonia and as to have a still purer tungstic oxide than he could buy commercially. Therefore, the ingredients of the Coolidge tungstic oxide after the Battersea treatment will be those and those only which are obtained from the Battersea crucible, and will be, hence, as the patent explains, largely alumina and silica. Of course, the patent teaches that there should be a substantial amount of this alumina and silica in the oxide before the oxide is reduced and made into a slug ready for mechanical working.

Q. 560. By that you mean the ingot?

A. The ingot, yes. He states that if it is less than 8/10 of one per cent on analysis, it should be refired so as to be sure to get .8 of a per cent of alumina and silica or more than that, even up to as high as one-half per cent if desired.

Q. 561. You tell me how he gets the ingot, with that patent?

A. In the Coolidge patent, this oxide, after firing, is reduced to metallic tungsten powder by reduction with hydrogen gas at a high temperature. This tungsten powder is then pressed into a briquette in a hydraulic press at high temperature. At that stage it is brittle and weak and does [fol. 341] not conduct electricity well. It is therefore handled with care and put in a furnace and heated in a hydrogen atmosphere to a white heat for a considerable time. After that heating, the briquette is stronger, can be han-

dled, and it also conducts electricity. It is then clamped between two clamps in a so-called treating bottle and again in a hydrogen atmosphere and electricity is passed through that briquette or slug and the slug is heated to a temperature, as he says, up to about 2800 degrees centigrade, brilliant white heat, nearly up to the melting point of tungsten. After that treatment he says the ingot is produced and then ready to work. That gives an ingot with small grain structure.

Q. 562. But non-offsetting?

A. The offsetting structure in the ingot would be of no moment. But if such a structure obtained in the final filament, it would be non-offsetting.

Q. 563. It would be non-offsetting but a small grain structure?

A. That is correct.

Q. 564. And would sag a little?

A. Yes, sir.

Q. 565. You found it sagging?

A. Yes.

Q. 566. Now, you take that Pacz patent and show me how you make that, up to the ingot, and point out as you go along, if you will, to me, so that I can understand the difference in the operation of making the ingot. Show me the difference between the Coolidge patent and that.

A. In the Pacz patent it is stated that the materials shall be left in intimate association with the tungsten oxid after the precipitation——

Q. 567. What difference is there in the tungsten oxid between the Coolidge patent and the Pacz patent, if there is any?

[fol. 342] A. I should say there is no difference in the beginning in the tungsten oxid.

Q. 568. You go along your steps in the Pacz patent and tell me as you make each step which one is different than the Coolidge patent, because I want to know how you get an ingot with a coarse grain structure in the Pacz patent?

A. No, the ingot is just as fine a grain or finer than in the Coolidge.

Q. 569. So to all practical purposes it is made the same way as the Coolidge patent?

A. No, differently.

Q. 570. Show me the difference, then, please.

A. The ingot in the Pacz process is prepared from an oxide which has been made with alkaline silicates present at the time of precipitation.

Q. 571. Instead of what?

A. Instead of having nothing present at the time of precipitation. Coolidge makes his tungsten oxid to begin with as pure as he can get it and then he puts in the ingredients of the Battersea crucible into that oxid by firing. Pacz purposely produces an alkaline tungstate, namely, a potassium sodium tungstate solution by preparing his solution A, described on page 1, lines 89 to 105 of the Pacz patent in suit, substantially as Mr. Laise testified; then he gets solution B, substantially as Mr. Laise testified.

Q. 576. Then he gets an ingot?

A. When he mixes solution A and solution B, he forms then for the first time an alkaline silicate. Up to solution A that is only the alkaline tungstate, but when he adds solution B he adds for the first time silicate from solution B. Then he prepares the oxide by precipitation with hydro- [fol. 343] chloric acid in the presence of the alkaline silicate and the precipitation of the tungsten oxid in the presence of the alkaline silicate causes some of the silica material to remain with the tungsten oxid even after the washing, which he describes as incomplete washing, namely, washing until the filtrate becomes milky.

The oxide which Pacz thus produces contains this alkaline silicate material intimately mixed with it as distinguished from the alumina and silica which is mixed with the Coolidge oxid after the Battersea crucible treatment.

Now there is a further difference in that Pacz teaches that his material is to be largely removed by volatilization while the ingot is being sintered. That means that the alkaline silicates contained in the Pacz oxide will boil out of the ingot while it is being heated to a high temperature and very little of that material will remain back in the finished ingot when it is ready to work. It is, however, a fact that it has imparted to the ingot a peculiar characteristic which is not understood so that when that ingot is worked down into wire and heated, the filament so produced develops these large crystals.

Q. 578. In other words, say that I have in my left hand an ingot made with the Coolidge process, as you have testified, and in my right hand an ingot made the way Pacz

teaches. Would you have two ingots that look the same—to the eye?

A. To the eye, they would look the same

Q. 579. What would be the real difference between those two ingots that you can describe in language that I can understand?

A. The main difference is under a high power microscope [fol. 344] in the Coolidge ingot you can see alumina particles on the one hand or thoria particles on the other which produces small grains when you draw the wire by retarding the crystal growth. You cannot see anything in the Pacz ingot under a microscope that gives you an indication of what it is going to do later. All you know is that later it gives you coarse grains of a peculiar type, long and angular and overlapping each other. I don't know what makes that happen. I have not found that out. From the time these two ingots are made until you draw the wire for filament purposes, the method used with both of these ingots, the Coolidge ingot and the Pacz ingot, are the same.

As Mr. Laise testified we add a beneficial ingredient like an alkaline silicate to the Pacz method, it is incorporated as I have just explained. The process in the Coolidge patent and the process in the Pacz patent with the materials mixed is what gives one the small grains, and the other the coarse grains. The Pacz patent describes that process. That gives a product that does not sag and does not offset. The Coolidge patent gave a product which did not offset but did sag somewhat. The difference between those two and the Schaller patent is that the wire is one complete grain—one grain instead of a number of grains.

Q. 594. Mr. Laise says that in this Pacz patent, if you make these ingots the way those letters patent tell you to make them, you do not get the filament that you put in these globes—is that what you said Mr. Laise—that you do some-[fol. 345] thing else to it that is not disclosed by that patent, is that so?

A. No, that is not true.

Mr. Darby: All I want your Honor to have clearly in mind—you must make, of course, the determination of fact—since your Honor has clearly in mind there is a sharp issue of fact between the witness as to whether or not there is or is not in the Coolidge Battersea process an alkaline silicate. Mr. Laise says there is, and Dr. Jeffries says there is not.

The Court: Oh, yes, I understand that. I asked him, Do you add a beneficial ingredient like an alkaline silicate to make the wire? Of course that is something for you to stress in your brief, Mr. Darby.

Mr. Darby: Dr. Jeffries has made one statement to your Honor in answer to your Honor's statement, which according to my recollection I have not covered in my testimony, and which was not covered by Mr. Laise's testimony.

The Court: Go right ahead and ask him.

Mr. Darby: Your Honor will appreciate that I want to safeguard against any witness saying something that we have not had an opportunity to either accept or deny.

The Court: Yes, you should have your record complete so I may be reviewed properly.

[fol. 346] Clements A. Laise, recalled by the defendant in sur-rebuttal, testified further as follows:

Direct examination.

By Mr. Darby:

Q. 386. Mr. Laise, Dr. Jeffries has made the statement in answering a question of the Court that the Schaller filament is not longer than a single crystal. Will you state whether or not that is a fact?

A. I have seen some Schaller filaments several feet long consisting of more than one crystal.

Mr. Darby: That is all.

(Witness excused.)

In United States District Court

Stipulation and Order Approving Narrative Statement of the Evidence

The foregoing narrative statement of the testimony, taken at the trial, having been presented to me, the same is hereby approved and allowed, and is ordered filed as a statement of the evidence to be included in the record on appeal, as provided by Equity Rule 75.

Dated, March —, 1937.

Matthew T. Abruzzo, U. S. District Judge.

Consented to. Howson & Howson, Attorneys for Plaintiff. Darby & Darby, Attorneys for Defendants.

[fols. 347-352] PLAINTIFF'S EXHIBIT No. 1

A. PACZ.
METAL AND ITS MANUFACTURE.
APPLICATION FILED [illegible], 1917.

1,410,499. Patented Mar. 21, 1922.

Fig. 1

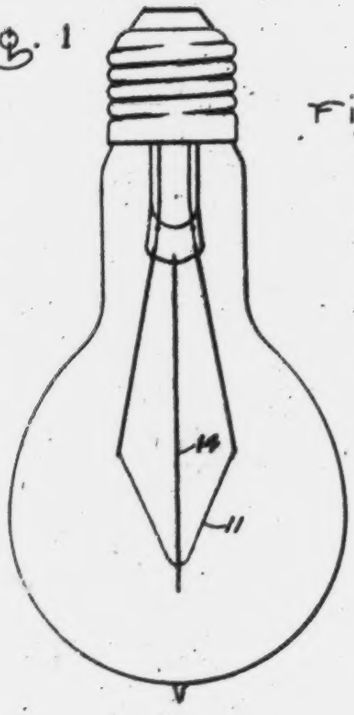

Fig. 4

Fig. 2

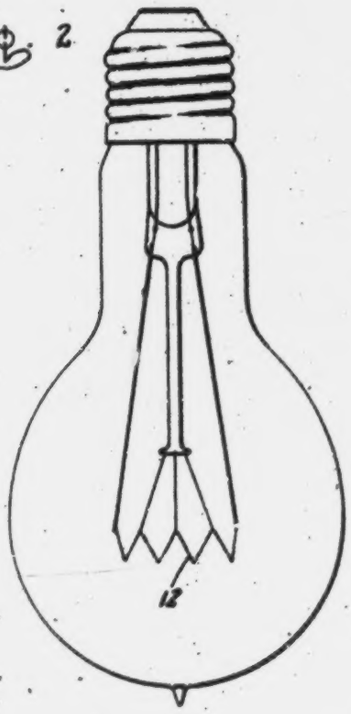

Fig. 3

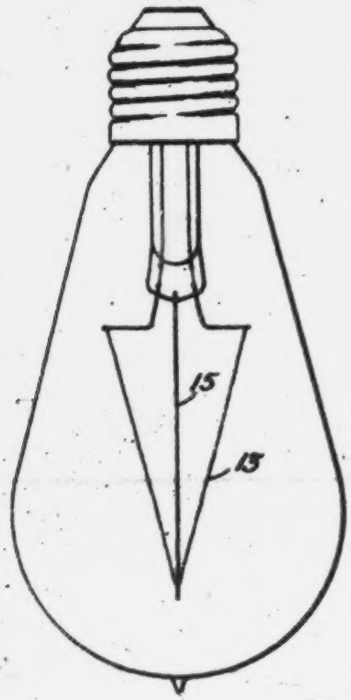

Fig. 5

INVENTOR
ALDAR PACZ
BY Allen H. Davis
His ATTORNEY

UNITED STATES PATENT OFFICE.

ALADAR PACZ, OF CLEVELAND, OHIO, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

METAL AND ITS MANUFACTURE.

1,410,499. Specification of Letters Patent. Patented Mar. 21, 1922.

Application filed February 20, 1917. Serial No. 149,915.

To all whom it may concern:

Be it known that I, ALADAR PACZ, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga, State of Ohio, have invented certain new and useful Improvements in Metals and Their Manufacture, of which the following is a specification.

The object of my invention is to produce tungsten metal which will retain to a much higher degree than heretofore its original properties after being subjected to high temperatures. In the case of incandescent lamp filaments, the high temperatures at which they are run have caused them to elongate and sag between their supports. This is especially noticeable in coiled filaments, and in gas filled lamps this tends to reduce the efficiency of the lamp on account of the increased cooling effect on the filament. By means of my invention the sagging is substantially eliminated and "offsetting" of the filament is substantially prevented, during a normal or commercially useful life of the lamp.

In the preferred form of my invention I bring into intimate association with tungsten a material which will have the desired influence upon the grain growth of the metal. I precipitate, simultaneously, compounds from which the metal is to be directly reduced with the material or compound which is to accomplish the desired result. The material after precipitation will remain in intimate association with the metal even after the same has been reduced by the ordinary means, i. e., reducing gases. During the subsequent formation of the metal into ingots or bars, the material should be such that it will be removed as by volatilization. A material should be used which will have a fairly high volatilization point which is preferably somewhat lower than the sintering point of the metal.

Considering my invention from the physical standpoint, the presence of the material has an influence on the grain growth of the metal. When the metal reaches the temperature at which extensive grain growth would ordinarily take place, the presence of this material intimately associated with the tungsten particles has a marked effect on the shape and size of the tungsten grains. The ingot of tungsten thus produced, whether it be due to the fact that the grains have not reached the equilibrium grain size or to other causes, is particularly susceptible to grain growth during subsequent heat treatments.

The probable reason why filaments made according to my invention do not sag, is that the structure is comparatively coarse grained. The coarse grained filament produced by means of my invention does not "offset" so as to cut short the life of the lamp appreciably.

As hereinbefore stated, the material which is intimately incorporated with the metal should be such that it will be volatilized out after the metal has reached the temperature of rapid grain growth. Tungsten above 1500° C. shows rapid grain growth, and I may use silica, or compounds containing it, as the material, incorporated very intimately as heretofore explained. By the time the tungsten has reached the sintering temperature the silica and the compounds containing it are volatilized out.

In order to comply fully with the requirements of the patent statutes, I will now describe one method or process embodying my invention and also modifications thereof. However, it is to be understood that the scope of my invention is such that many changes and substitutions will readily suggest themselves to those skilled in the art, and, as indicated, in the appended claims, are to be considered as forming part thereof.

A fusion of materials is first made which is quite similar to that disclosed in my Patent Number 1,299,017 issued April 1, 1919. 1400 grams of commercial tungstic acid, 620 grams commercial sodium carbonate, 620 grams commercial potassium carbonate, and 300 grams commercial sodium nitrate are mixed with water to a paste. I have found that half or more of the potassium carbonate may be replaced by sodium carbonate without affecting the results, the object being to obtain a good fusion. This paste is dried on a hot plate and fused with a torch for about fifteen minutes, after which the fusion is dissolved in water, filtered and diluted to about six liters. This we will term solution A.

A mixture is then made of 180 grams commercial silicic acid, 620 grams commercial K_2CO_3 and 150 grams commercial $NaNO_3$ with water to a paste which is dried and fused. The object is to produce a silicate

which will be readily incorporated with the tungstic acid in the subsequent portion of the process. An alkaline silicate such as produced by the specific example given is readily soluble and efficacious for this purpose. The fusion is dissolved in water, filtered and diluted to 5 liters. This may be termed solution B.

About 250 cubic centimeters of solution B are added to 3 liters of solution A. The whole solution is then boiled with steam and poured into a boiling solution containing about 1500 cubic centimeters of HCl and 1500 cubic centimeters of H_2O, preferably through a funnel. The precipitate is allowed to settle, the liquid decanted, and the precipitate separated by filtration. The precipitate is then washed with hot H_2O until the filtrate becomes milky. The precipitate is then dried and ignited in a quartz dish. It is reduced in hydrogen in boats, each boat containing about 100 grams. The metal thus produced may be termed metal A.

The metal A may be pressed up and sintered to produce tungsten slugs which may be drawn into filaments having the non-sag and other characteristics hereinbefore described. I prefer, however, in order to obtain greater uniformity of product to continue the operation as follows:

About 1200 grams of metal A are mixed with about 1200 grams of the oxide from which metal A was reduced, the mixture being very intimate and being performed preferably in a tumbling mill. The mixture is then reduced as before although 150 gram charges may be here used. The metal thus produced may be termed metal B. It is then sieved, pressed into ingots and sintered in the usual way as set forth in the Coolidge Patent No. 1,082,933.

As a modification of the above described process, solution B may be added directly to the fusion from which solution A is made. This is preferably done by utilizing the proper proportion as heretofore stated of solution B in making the paste which is dried and fused and dissolved to form solution A.

The metal obtained from the first method above described I have called "218", a purely arbitrary name. I have produced a metal differing in appearance and physical characteristics from "218" metal by adding a solution of boric acid to chemically pure WO_3, evaporating, drying, igniting and reducing. The metal thus produced when made into wire is not superior to "218" in non-sagging or non-offsetting characteristics, but a combination of this method with that for producing "218" in which the WO_3 from the latter is mixed with that from the former produces a metal which I term "Z" and which is efficacious in the production of non-sagging and non-offsetting filaments. To produce this metal one method which I have practiced is to mix 1 kilogram of the tungstic oxide from which metal A is reduced in the "218" process with a solution of 12.5 grams fused B_2O_3 in 500 cubic centimeters of water. This mixture is evaporated, dried, ignited and reduced. The resulting metal is blacker than "218", flows more readily and possesses at least one-third larger volume than "218" although reduced under exactly the same conditions.

The tungsten ingots produced according to my invention usually have fine grains, as for example, between 2500 and 6500 grains per square millimeter. In the case of the "218" ingots analyses have shown that the percentage of non-metallic material is below two-tenths of one per cent and in many cases below one-tenth and even one-twentieth of one per cent.

When the tungsten metal produced by any of the methods above described is to be made into a filamentary body, the method described in the Coolidge Patent No. 1,082,933 for drawing or otherwise working down the ingots is practiced. Where the wire is to be used at high temperatures such as in incandescent electric lamps it should be given a preliminary heat treatment or aging. This helps to secure the non-sag characteristics of the wire made according to my invention. One procedure followed with good results with the ordinary 110–115 volts lamps was to run at 30 volts for 2 minutes and then at steps of 5 volts each for two minutes up to 60 volts. After this the wire was run at 115% voltage for 15 minutes.

In the accompanying drawing I have shown, in elevation, lamps, the filaments of which are made according to my invention. Figs. 1, 2 and 3 are front elevations of these lamps, while Figs. 4 and 5 are partial side elevations showing the filaments and supports. All of these lamps may be of ordinary voltage, i. e. 110 volts, and of any of the ordinarily used wattages. The lamps shown in Fig. 1 and Fig. 2 are of the gas-filled type disclosed in the Langmuir Patent No. 1,180,159, and have coiled filaments 11 and 12. The lamp shown in Fig. 3 is a vacuum lamp having the coiled filament 13. The support 14 is provided for the single loop filament 11 and the support 15 for the singe loop filament 13. Heretofore it was impractical to make a lamp like this, having a single coiled loop filament for use at ordinary voltages. The non-sag characteristics of my wire render this construction possible for all of the ordinary voltages and wattages.

The tests on 50 and 100 watt lamps embodying the construction shown in Figs. 1 and 2 of the drawing show that subetantially all of the sagging occurs during the aging of the lamp. This is when the lamp filament is

given the heat treatment hereinbefore referred to. The sagging was greater in the case of the construction shown in Fig. 1 than in that shown in Fig. 2 on account of the fact that in the latter there are more supports. In the construction shown in Fig. 1 in the case of 50 watt 115 volt lamps in which the filament was 1.62 mils in diameter and which was made by coiling on a mandrel of 5 mils diameter, the turns per inch originally ran from 421 to 430 and after aging the average decrease in the number of turns per inch was from 18 to 24. This was under 5%. In the case of the construction shown in Fig. 2 the decrease was from 1 to 6 turns, or under 2%. In the case of 100 watt 115 volt lamps. in which the filament diameter was 2.63 mils and the filament was shaped by coiling upon an 8 mil mandrel the number of turns per inch originally ran from 257 to 269. After aging, in the case of the construction shown in Fig. 1 the decrease in number of turns was from 0 to 10 or less than 5% and in the case of construction shown in Fig. 2 it was from 0 to 6 turns per inch, or less than 3%. In one case, after total life of a 100 watt lamp, the number of turns decrease in the case of the construction shown in Fig. 1 was 12, while in the construction shown in Fig. 2 it was 4.

What I claim is:

1. The process of producing substantially non-sagging and non-offsetting tungsten filaments, which includes intimately associating finely divided tungsten and a material which volatilizes mainly at temperatures within the range of rapid grain growth of the tungsten and thereafter sintering the tungsten into a coherent body.

2. The process of producing substantially non-sagging and non-offsetting tungsten filaments, which includes intimately associating finely divided tungsten and a material which volatilizes mainly at temperatures within the range of rapid grain growth of the tungsten, thereafter sintering the tungsten into an ingot, and working such ingot into filament form.

3. The process of producing substantially non-sagging and non-offsetting tungsten filaments, which consists in reducing a tungsten oxide intimately associated with a material which volatilizes mainly at temperatures within the range of rapid grain growth of the tungsten and thereafter producing a coherent body by sintering a compacted body of the product of such reduction.

4. The method of producing substantially non-sagging and non-offsetting tungsten filaments, which includes producing a coherent body of tungsten by sintering finely divided tungsten having intimately associated therewith a compound or compounds containing silicon and oxygen and volatilizing mainly at temperatures within the range of rapid grain growth of the tungsten.

5. The method of producing substantially non-sagging and non-offsetting tungsten filaments, which includes producing a coherent body of tungsten by sintering finely divided tungsten having intimately associated therewith a compound or compounds containing silicon, oxygen and an alkali metal, and volatilizing mainly at temperatures within the range of rapid grain growth of the tungsten.

6. The method of producing substantially non-sagging and non-offsetting tungsten filaments, which includes producing a coherent body of tungsten by sintering finely divided tungsten having intimately associated therewith a compound or compounds, containing silicon, oxygen and potassium, and volatilizing mainly at temperatures within the range of rapid grain growth of the tungsten.

7. The method of producing tungsten filaments, which includes producing an ingot by heating finely divided tungsten having intimately associated therewith a compound or compounds, containing silicon and oxygen, and volatilizing mainly at temperatures within the range of rapid grain growth of the tungsten, and thereafter working said ingot down to filament form.

8. The method of producing tungsten filaments, which includes producing an ingot by sintering finely divided tungsten having intimately associated therewith a compound or compounds, containing silicon, oxygen and an alkali metal, and volatilizing mainly at temperatures within the range of rapid grain growth of the tungsten and thereafter working said ingot down to filament form.

9. The method of producing tungsten filaments, which includes producing an ingot by sintering finely divided tungsten having intimately associated therewith a compound or compounds containing silicon, oxygen and potassium, and volatilizing mainly at temperatures within the range of rapid grain growth of the tungsten, and thereafter working said ingot down to filament form.

10. The method of producing tungsten filaments, which includes reducing a tungsten oxide intimately associated with a compound or compounds containing silicon and oxygen, and volatilizing mainly at temperatures within the range of rapid grain growth of the tungsten, and thereafter producing a coherent body by sintering a compacted body of the product of such reduction.

11. The method of producing tungsten filaments, which includes reducing a tungsten oxide intimately associated with a compound or compounds containing silicon, oxygen and an alkali metal, and volatilizing mainly at temperatures within the range of rapid grain growth of the tungsten, and

thereafter producing a coherent body by sintering a compacted body of the product of such reduction.

12. The method of producing tungsten filaments, which includes reducing a tungsten oxide intimately associated with a compound or compounds containing silicon, oxygen and potassium, and volatilizing mainly at temperatures within the range of rapid grain growth of the tungsten and thereafter producing a coherent body by sintering a compacted body of the product of such reduction.

13. The method of producing tungsten filaments, which consists in reducing a tungsten oxide intimately associated with a compound or compounds containing silicon and oxygen and volatilizing mainly at temperatures within the range of rapid grain growth of the tungsten, producing an ingot by sintering a compacted body of the product of such reduction and working down the said ingot.

14. The method of producing tungsten filaments, which consists in reducing a tungsten oxide intimately associated with a compound or compounds containing silicon, oxygen and an alkali metal and volatilizing mainly at temperatures within the range of rapid grain growth of the tungsten and producing an ingot by sintering a compacted body of the product of such reduction and working down the said ingot.

15. The method of producing tungsten filaments, which consists in reducing a tungsten oxide intimately associated with a compound or compounds containing silicon, oxygen and potassium and volatilizing at temperatures within the range of rapid grain growth of the tungsten and producing an ingot by sintering a compacted body of the product of such reduction and working down the said ingot.

16. The process of producing substantially non-sagging and non-offsetting tungsten filaments, which includes intimately associating tungsten oxide and a material which volatilizes mainly at a temperature within the range of rapid grain growth of tungsten, reducing a portion of said oxide to metal, mixing said metal with another portion of said oxide, reducing said mixture, and working the product of said reduction into filamentary form.

17. The process of producing substantially non-sagging and non-offsetting tungsten filaments, which includes preparing tungsten oxide intimately associated with an alkali metal and an oxide of silicon, reducing said tungsten oxide to metal, mixing said metal with another portion of said oxide, reducing said mixture, and working the product of said reduction into filamentary form.

18. The process of producing substantially non-sagging and non-offsetting tungsten filaments, which includes preparing tungsten oxide intimately associated with potassium and an oxide of silicon, reducing a portion of said oxide to metal, making a mixture of said metal and another portion of said oxide, reducing said mixture, and working the product of said reduction into filamentary form.

19. The process of producing substantially non-sagging and non-offsetting filaments, which includes precipitating a tungsten compound from a solution containing as constituents an alkali metal and a silicon oxide and reducing the precipitate substantially to tungsten metal.

20. The process of producing substantially non-sagging and non-offsetting filaments, which includes precipitating a tungsten compound from a solution containing as constituents an alkali metal and a silicon oxide, reducing the precipitate substantially to tungsten metal, forming an ingot therefrom and working the same into filament form.

21. The process of producing substantially non-sagging and non-offsetting filaments, which includes precipitating a tungsten compound from a solution containing as constituents potassium and a silicon oxide and reducing the precipitate substantially to tungsten metal.

22. The process of producing substantially non-sagging and non-offsetting filaments, which includes precipitating a tungsten compound from a solution containing as constituents potassium and a silicon oxide, reducing the precipitate substantially to tungsten, forming an ingot therefrom and working the same into filament form.

23. A tungsten filament containing materially less than three-fourths of one per cent of non-metallic material and substantially free from sagging and offsetting during a normal or commercially useful life.

24. A coiled tungsten filament containing materially less than three-fourths of one per cent of non-metallic material and substantially free from sagging and off-setting during a normal or commercially useful life.

25. A filament for electric incandescent lamps or other devices, composed substantially of tungsten and made up mainly of a number of comparatively large grains of such size and contour as to prevent substantial sagging and offsetting during a normal or commercially useful life for such a lamp or other device.

26. A drawn filament for electric incandescent lamps or other devices, composed substantially of tungsten and made up mainly of a number of comparatively large

grains of such size and contour as to prevent substantial sagging and off-setting during a normal or commercially useful life for such a lamp or other device.

27. A filament for electric incandescent lamps or other devices, composed of tungsten containing less than three-fourths of one percent of non-metallic material and made up mainly of comparatively large grains of such size and contour as to prevent substantial sagging or offsetting during a normal or commercially useful life for such a lamp or other device.

28. A coiled filament composed substantially of tungsten and capable of use in an electric incandescent lamp without either substantial sagging or offsetting during a normal or commercially useful life.

29. A coiled filament composed mainly of drawn tungsten and capable of use in an electric incandescent lamp without substantial sagging and without substantial offsetting during a normal or commercially useful life.

30. A drawn filament composed mainly of tungsten and capable of use in an electric incandescent lamp without substantial sagging and without substantial offsetting during a normal or commercially useful life.

31. A filamentary body composed substantially of tungsten and adapted to be mounted in an incandescent electric lamp and after it has been aged, capable of a normal or commercially useful life without substantial sagging and without substantial offsetting.

32. A drawn tungsten wire adapted for use as an incandescent lamp filament and capable after aging, of a normal or commercially useful life without substantial sagging and without substantial offsetting.

In witness whereof, I have hereunto set my hand this 16th day of February, 1917.

ALADAR PACZ.

DISCLAIMER

1,410,499.—*Aladar Pacz*, Cleveland, Ohio. METAL AND ITS MANUFACTURE. Patent dated March 21, 1922. Disclaimer filed November 10, 1933, by the assignee, *General Electric Company*.

Therefore enters this disclaimer to so much of the statement on lines 52 to 59 of page 2 of the printed patent specification as might imply or tend to imply that by "adding a solution of boric acid to chemically pure WO_3, evaporating, drying, igniting and reducing" alone, it is possible to produce commercially useful non-sagging and non-offsetting tungsten filaments.

[*Official Gazette December 5, 1933.*]

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[fols. 353-363] PLAINTIFF'S EXHIBIT No. 2

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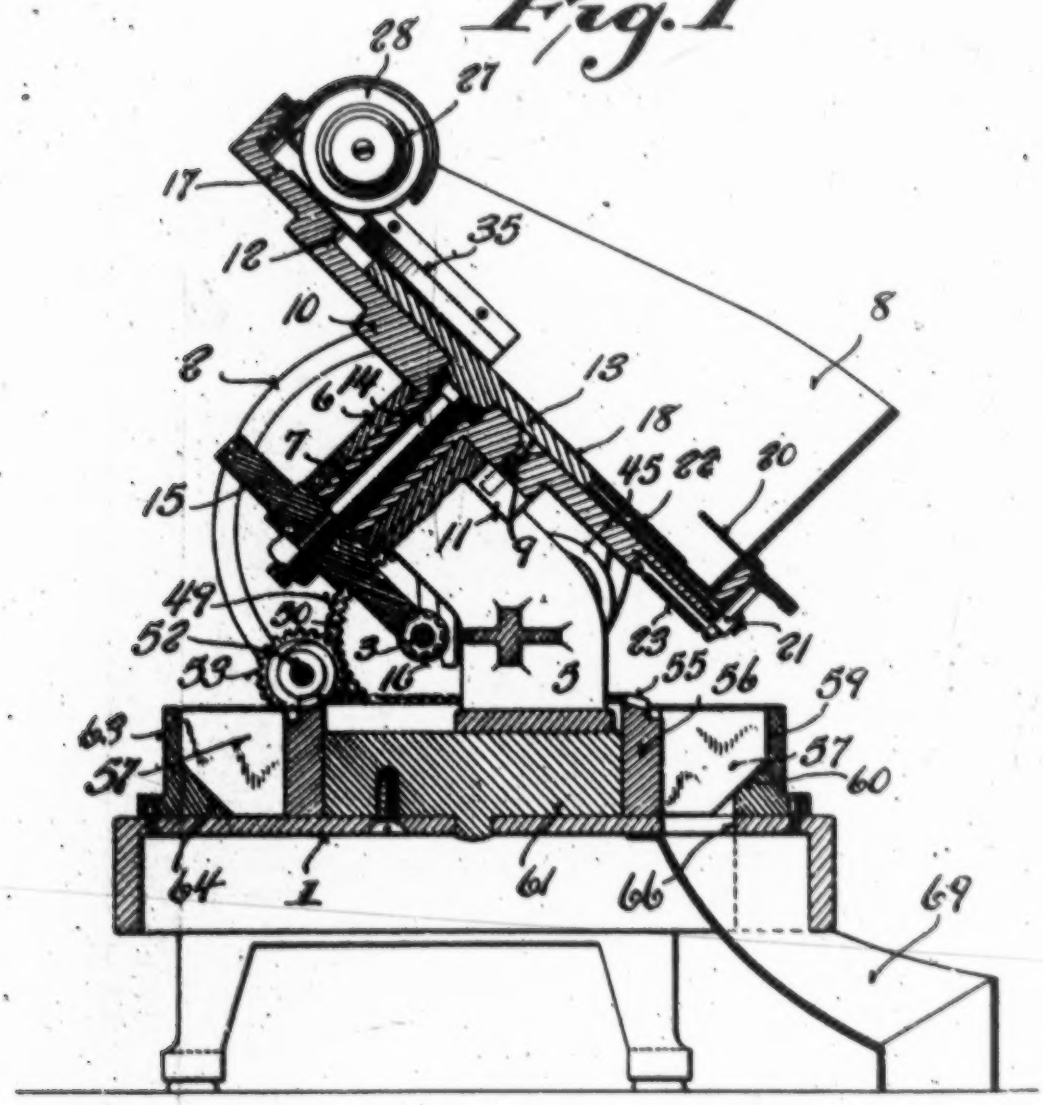
Feb. 17, 1925. 1,526,762

C. SCHWARTZ

COIN SORTING MACHINE

Filed May 3, 1923 6 Sheets-Sheet 1

Fig. 1



Witnesses:
R. E. Weber

Inventor:
Carl Schwartz
By
Attorneys

UNITED STATES PATENT OFFICE.

WILLIAM D. COOLIDGE, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

TUNGSTEN AND METHOD OF MAKING THE SAME FOR USE AS FILAMENTS OF INCANDESCENT ELECTRIC LAMPS AND FOR OTHER PURPOSES.

1,082,933. Specification of Letters Patent. Patented Dec. 30, 1913.

Application filed June 19, 1912. Serial No. 704,580.

To all whom it may concern:

Be it known that I, WILLIAM D. COOLIDGE, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Tungsten and Methods of Making the Same for Use as Filaments of Incandescent Electric Lamps and for other Purposes, of which the following is a specification.

This application is in part a continuation of my prior applicatons, Serial Number 324,335, filed July 2, 1906; Serial Number 521,220, filed October 6, 1909; Serial Number 545,274, filed February 23, 1910; and Serial Number 577,353 filed August 15, 1910.

My invention comprises a new incandescent lamp filament of drawn wire made from the metal tungsten, and a process of producing the same. I have been able to produce from this refractory, brittle, non-ductile and generally unworkable metal a wire which is tough, fibrous and elastic and of high tensile strength, and have thus been able to facilitate the manufacture and improve the quality of tungsten incandescent electric lamps.

The wire produced by my invention has found various other applications, and may be used wherever high tensile strength, freedom from corrosion, or ability to withstand high temperatures are of value. So also the new material of which the wire consists, fully worked ductile tungsten, has in other mechanical forms a wide variety of useful applications. Further, an incidental but valuable new product is found at an intermediate stage of my process, in tungsten which is wrought, but in which the working process has been interrupted before the above described properties have fully developed but at a point where desirable properties not found in any tungsten of the prior art have been developed to an amount sufficient for the purposes for which the material in question is to be used.

The metal tungsten is described in standard works on chemistry and metallurgy as obtained in the form of a steel-gray to black powder, having a fusing point of about 3200 degrees C. It is stated to be entirely non-ductile. Thus, for example, Roscoe and Schorlemmer's *Treatise on Chemistry*, vol. 11, p. 1058, published in 1907, cites the work of Moissan, but states that: "The purest forms of tungsten at present obtainable are hard and brittle, and are not ductile either at ordinary temperatures or when heated." De Lodyguine's Patent No. 575,002, referring to tungsten, states (page 1) that it is "almost absolutely non-ductile" and "cannot be drawn out into wires in the manner employed in operating on ductile metals". Also, the British patent of Siemens & Halske Aktiengesellschaft, No. 5387 of 1908, and British patent of Consortium fur Elektro-Chemische Industrie, of Nurnberg, Germany, No. 3938, of 1907, state that tungsten is non-ductile and cannot be drawn into wires.

Up to the time of my present invention all efforts to work the metal have failed, and no one had succeeded in modifying its characteristic hard brittle structure. Incandescent lamp filaments had been made of tungsten by means of a sintering process, that is, by pressing up tungsten powder with or without a binder into the desired shape, and then consolidating it at a high temperature by passing electric current through it. Filaments so formed have been of exceedingly low strength and very brittle.

I have discovered a process by which tungsten bodies, when prepared under certain conditions, as will be hereinafter more fully described, can be mechanically worked as by hammering, swaging, rolling and drawing, and have further discovered that when this mechanical working is carried on while the metal is heated to temperatures within certain maximum and minimum limits and is continued long enough, such bodies will be converted from their original crystalline character to a condition having all the characteristics of a ductile metal. In other words, the repeated hot working so changes the metal that it acquires tensile strength and also becomes pliable and ductile at ordinary or room temperatures, and if the mechanical working is carried sufficiently far, and under proper conditions, the tensile strength of the metal may become equal to or greater than that of the best steel. I have thus not only devised a new process by which it has become possible to work tungsten, as by hammering it or rolling it into the desired form, and by drawing it into fine strong wire, but I have

also produced by the operation of this process a new product, viz: wrought tungsten, and, if the process be carried far enough, ductile tungsten, a material having properties and utilities different from those of any previously known substance. When it is desired to produce from this material an incandescent lamp filament, or any other body which in normal operation is to be operated at high tempertures, I use a special mode of preparation in order to minimize the tendency of the tungsten to revert to a brittle crystalline form. When this crystallization becomes excessive the crystals may, in the case of a filament, become so large as to extend across the entire section of the filament and thereupon the sections may move laterally upon each other and produce the condition known as "offsetting". I shall hereinafter describe more in detail the special method which I employ for minimizing the loss in ductility and for preventing this offsetting effect.

My process divides itself into two stages, first the preparation of an ingot or billet of tungsten, and second the working of the ingot, and I find that the more successfully the ingot is prepared the more quickly and readily it can be worked. Also, by using certain precautions in working I am able to handle ingots which have not been prepared in the best possible way. I have no doubt that with the progress of the art improvements will be made in my process whereby the ingot will be so prepared that its working becomes much easier than it now is, or whereby, through improvements in the working, less care and skill will be required in the preparation of the ingots. I will, however, first describe in detail a process which I have worked successfully on a large scale for the production of drawn tungsten wire of the highest quality suitable for filaments for incandescent lamps and by means of which a single tungsten wire seven miles long has been produced, and will thereafter describe certain of the numerous modifications of the process, within the scope of my invention, which may be resorted to as occasion requires.

In describing this process I will refer to the accompanying drawings in which—

Figure 1 shows a swaging machine, Figs. 2 and 3 are detailed views showing different forms of swaging dies; and Fig. 4 is a view of one form of wire-drawing apparatus, and Fig. 5 shows an electric furnace, and Fig. 6 is a view of an incandescent lamp made in accordance with my invention.

Starting with tungstic oxid (WO_3) as pure as commercially obtainable, I dissolve it in ammonia water and thus form ammonium tungstate, which is purified by crystallization over a steam bath and is then, after washing by distilled water and drying, decomposed by the application of moderate heat, say 400 to 500 degrees C. which drives off the ammonia and leaves purified tungstic oxid. The tungstic oxid thus purified is heated in a gas furnace for about five hours in a covered Hessian or Battersea crucible of the ordinary and well known type, after which step it is found to be coarser and of higher density and to contain matter, probably volatilized from the crucible, the effect of which, as will be hereinafter explained, is beneficial. The substances thus added to the oxid of tungsten, which for convenience I may designate as additions, consist largely of alumina, and silica. I have obtained best results when these additions occurred in the proportion of from 0.8 to 1.5 of one per cent.

If on analysis it is found that less than say 0.8 of one per cent. of additions is present, the operation of firing in the Hessian or Battersea crucible is repeated as many times as may be necessary a new crucible being used each time. The material, which has somewhat melted and agglomerated into a mass, is ground after each firing.

The next operation is performed in a tube, for example of porcelain or fused quartz, having a diameter of one and one-half inches and a length of two feet. This tube is packed nearly full of tungstic oxid except that clear spaces are left at each end, and the tube is gradually raised by suitable gas burners or by electrical heating, in six or seven hours, to a temperature which may be between 900 degrees C. and 1150 degrees C. I may if preferred use the type of furnace described by Winne and Dantsizen in the *Transactions of the American Electrochemical Society*, vol. XX, 1911, pp. 289–90. Crystallinity in the metal powder is to be avoided and this result is aided by this slow raising of temperature. Pure, dry hydrogen passes through the tube during this heating operation for a period of say six to fifteen hours, and is preferably introduced through a small passage formed in the upper part of the charge next to the containing tube; which arrangement leaves a thick body of the charge to be acted upon by the hydrogen. In this operation the tungstic oxid, or as it is called the "yellow oxid," is progressively reduced to the blue oxid and then to the brown oxid and then to the pure metal. The powdered tungsten thus formed is inserted, in weighed quantities, into a steel mold and is by means of a hydraulic press pressed into sticks or rods which may for example be ¼ of an inch square and six inches long, though good results have also been obtained with octagonal rods.

The mold is of extreme strength and rigidity and is arranged to apply the pres-

sure transversely of the stick to be formed. The powder is evenly placed in the mold so that the sticks shall be of uniform density from end to end.

When the pressure is removed the mold is split or opened and the pressed tungsten stick is gently slid on to a strip for example of molybdenum or tungsten and introduced into a tube of some such material as porcelain or alundum electrically heated by a winding of tungsten or platinum wire, in which apparatus the tungsten stick is fired in an atmosphere of hydrogen to a temperature of say 1200 degrees C., for from ten minutes to an hour, or long enough to permit the sticks to become strong, so that they may easily be handled. The molybdenum support may be withdrawn when the stick has been brought to a bright red heat.

The pressing operation which I have just described is performed with dry tungsten powder but I may if desired use a binder which must afterward be removed. If the binder is carbonaceous, the carbon may be removed by heating the sticks in moist hydrogen or if desired in hydrogen containing a small amount of air.

If the tube in which the heating or firing operation is performed is made of porcelain, I fire the stick on a "boat" of suitable material such for example as molybdenum.

The fired sticks are then placed, one at a time, in a closed treating vessel, ordinarily of copper and similar to those commonly used in sintering tungsten filaments, but larger and of more rugged construction, through which hydrogen or other reducing atmosphere is constantly passed, and an electrical current is passed through them sufficiently intense to raise them to a blinding white heat. This sinters the stick and converts it into a coherent slug of metal. While in the treating vessel the sticks are held in water-cooled spring clamps, one of which is carried by a fixed support while the lower one dips into a water cooled pool of mercury so as to adjust its position as the stick shortens up during sintering. In some cases I water cool the bottle itself, and I find it best to cover the lower edges of the bottle with a mercury seal.

I prefer with the ¼ inch rod six inches long to sinter at 1700 to 1800 amperes (alternating) for fifteen minutes, the current being gradually raised to this point in say about five minutes, and then to reduce the current by degrees until at the end of one minute or more it is cut off altogether, whereupon the rod may be withdrawn as soon as it cools sufficiently to allow the treating vessel to be opened. This slow reduction of the current is intended to prevent a sudden reduction of gas pressure in the treating or sintering vessel, which would tend to draw in air and produce an explosion. After the sintering operation, the ends of the slug held by the clamps and therefore but partially sintered, are broken off. This completes the preparation of the slug or billet.

The next step is the mechanical working, which, in the particular process I am now describing, is carried on as follows: In Fig. 1 A is a swaging machine which may be of the general type shown in United States patent to Dayton, No. 515,576, February 27, 1894. In this machine the head B is rotated and a pair of dies each like the dies shown for example in Fig. 2 or Fig. 3 are brought together and then separated several times in each revolution. The head B carries the swaging dies and their operating mechanism and through the machine extends a horizontal passage D for receiving the work as it passes through the dies. The dies C, unlike the ordinary swaging dies, have very short faces E, about equal in length to the diameter of the tungsten piece passing between them. The edges C' in the working surfaces are rounded or "backed off" to keep the die from digging into the rod. In some cases a die may be used having a peculiar form of face, shown in Fig. 3, in which the edges of the striking portion or face of the die are rounded off gradually.

In Fig. 5, F is a tube furnace of the type described in the Winne and Dantsizen article above referred to. It consists of a tube G of alundum or porcelain; a winding of wire H of platinum or preferably tungsten or molybdenum through which an electric current may be passed, and a heat insulating cover K of magnesite, fine silica or other suitable material held by a suitable shell or casing of asbestos, fire brick, sheet iron or the like. Hydrogen is passed through the tube G in any suitable way as by the pipe I. The operator grasps with a pair of tongs one of the tungsten billets or slugs and inserts it in the furnace, which is in some convenient location near the swager, and leaves it there until it attains a high temperature, say 1300 to 1700 degrees C., and at which, when the billet is removed from the furnace into the open air, it gives off a cloud of volatilized oxid of tungsten. He then takes the smoking hot billet with the tongs and quickly thrusts it as far as he can into the swaging machine and as quickly withdraws it. The swaging machine runs at high speed and care should be taken to keep the slug in rapid motion into and out of the dies so as not to cool it materially. The dies are chosen so that each shall produce only a slight decrease in the cross-section of the billet and if the billet is square it is necessary to use care in passing from the square to the circular form, which form is of course produced by the action of the dies, and ordinarily the

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dies should be so adjusted that several passes through different dies occur in the production of the circular form.

The billet after being inserted in the first dies is reheated in the furnace, then grasped by the other end and, without changing the dies, quickly thrust into the swaging machine, and quickly withdrawn as before. As many billets as may be ready for treatment are thus manipulated and then the dies are removed and other dies are inserted arranged to produce a somewhat smaller section, and so on.

Starting with the ¼ inch square billet, I am able with five (5) passes through the machine to obtain a circular rod of 210 mils. in diameter. From 210 mils. to 60 mils. I ordinarily proceed by ten steps. As the billet becomes longer and smaller in diameter I may use a gas furnace or heater instead of the electric furnace and a smaller size swaging machine, and the billet, which is now a wire or rod, is drawn by the action of mechanically driven feed rollers through the gas flame of a gas furnace, which is then located in front of the swager, and through the swaging dies, passing completely through the opening corresponding to D in Fig. 1, and when this arrangement is adopted only one pass is necessary with each die setting.

The swaging operation is continued, with continual reduction of the dies, until in six or seven more operations the wire has been reduced to thirty mils. diameter. The temperature to which the rod is heated, which was originally at white heat, is reduced at the diameter of about 40 mils. to a yellow red and this temperature is maintained to the end of the swaging operation; that is to say until a diameter of 30 mils. has been reached. At or by this time the material has become ductile at room temperature and can be bent and otherwise manipulated.

The wire drawing die L, Fig. 4, consists of a drilled diamond set in metal, held by supports M and heated by a number of gas jets N. The wire is pointed by dipping the end in fused potassium nitrite, as is disclosed in the Whitney Patent No. 1,008,762, and the pointed end is then inserted in the die and grasped by the clamp O, which may be heated at the point where it holds the wire by a gas jet P, or the operator may merely grasp by a pair of pliers the end of the wire where it emerges from the die and pull a few feet of it through the die and attach the end to a spool or spindle which is revolved by power. In this manner the whole length of the wire resulting from the swaged billet is drawn through the die, but before it passes through the die it should pass through a bath of a material known as aqua dag, which I understand is a deflocculated graphite suspended in water, or of oil dag, which is a similar preparation in which oil is used instead of water as a suspending medium. This is done in the manner set forth in the Dempster Patent No. 1,022,132. The die should be at a temperature of 600 to 650 degrees C. and the wire should be red hot both when going into the die and when emerging therefrom.

Further reduction is accomplished in the same way, the dies varying by one mil. steps down to 14 mils., making 16 drawing operations from 30 to 14 mils. At 14 mils. or thereabout the temperature of the dies may be reduced below a red heat, but the wire itself is run red hot through the die down to sizes approximating 3 mils.

From 14 to 5.5 mils. the dies should vary in steps of one-half of a mil., making 17 additional operations; from 5.5 mils. to 4 mils. there are five operations with steps of ¼ of a mil.; from four mils. to 2 mils. there are 0.2 of a mil. drafts; and from 2 mils. to 1.4 mils. there are six operations with steps of $\frac{1}{10}$ of a mil.; and from 1.4 mils. to 0.5 mil. there are 18 operations with one twentieth of a mil. draft.

As the wire reaches smaller sizes the method of pointing described in the Whitney patent above mentioned becomes inconvenient, and instead the wire is dipped in a strong solution of potassium cyanid, and current is passed through the wire in such a direction as to make it an anode. Of course the wire drawing may be stopped at any stage according to the size of wire desired.

The metal obtainable as the ultimate result of the operations above described is a new product differing radically from any form of tungsten heretofore obtained. Not only is it pliable and ductile at room temperature, but it is strong and tough. It is substantially non-oxidizing in moist air at ordinary temperatures and resists the action of acids to an unusual degree. Its specific gravity is higher than that of sintered tungsten and has been found in certain samples to run from 19.15 to 19.3. It has an exceedingly high tensile strength, as high in particular samples of .001″ diameter as 600,000 to 650,000 lbs. per square inch, is non-magnetic and not easily corroded, and is elastic and resilient.

The material has a wide variety of technical uses. If used for filaments of incandescent lamps, it may be mounted as described in the Feuerlein Patent, No. 819,009, April 25, 1906, as shown in Fig. 6 of the drawings hereto attached. Before this is done, however, the wire may if desired be freed from impurities on its surface in some suitable manner as by passing it through a bath of hot caustic soda and then through a suitable wiper. When run in the lamp the drawn tungsten filament made as described

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loses much of its strength but is then, if carefully prepared in accordance with the directions herein given, nevertheless a much stronger filament than that made by ordinary squirting processes. To guard against this loss in strength, the filament should not be run at a very high temperature in the lamp until the lamp has been sealed off from the evacuating pump.

If my new material is used as the target of an X-ray tube it gives the tube a life and constancy of vacuum far superior to that possible by the use of a target of any other known material. It presents many advantages for use as contacts for magnetos and other devices where making and breaking of a circuit occurs, and is for such purposes far preferable to platinum and other materials now in use.

For certain applications the complete working process resulting in an entirely ductile metal of great tensile strength is not required. For example, after a certain amount of rolling or swaging, depending on the amount of softness and strength which the metal should have for the purpose for which it is to be used, or without any swaging or rolling whatever if great strength is not necessary in the finished product, I can heat the metal, for example in an alundum tube furnace, and hammer it into any desired shape, shear it, or roll it into plates, and from these plates I can punch parts of any desired configuration provided that the material has been prepared in accordance with the directions above given, and that the operation, whatever it may be, is performed, except in cases where the fiber has been very thoroughly developed by long-repeated mechanical working, at a sufficiently high temperature. When I have desired to produce a number of identical pieces I have resorted to a drop-forging operation.

The metal produced even by incomplete working differs markedly from any form of tungsten heretofore known, for example, it is stronger and tougher and less liable to cracking on unequal heating and cooling. When the working is fairly complete, the crystals characteristic of sintered tungsten have been deformed, broken up and elongated to such an extent that the structure is fibrous. When the working is less complete the crystals are broken up, though to a less extent, and are deformed as by elongation or flattening, according to the nature of the working process. When, for example, the billet is hammered into a plate or sheet, the crystals are found to have become flattened.

An important point in practising the above described method of carrying out my invention is the temperature to which the metal is raised and at which the several operations are carried on. Where it is desired that the resulting metal shall have the properties of a wrought metal more or less pliable and ductile at ordinary temperatures, it is not only necessary to repeat the mechanical working a large number of times, but it is necessary to keep at all times within a certain range of temperature at least during the later stages of working. It is necessary, on the one hand, that the temperature be high enough to make it possible to mechanically work the body, but, on the other hand, too high a temperature is objectionable because if the temperature is too high a tendency appears to lose fiber already acquired and to pass to a state of brittleness from a state of ductility. The range of temperatures within which properly prepared tungsten bodies may be worked to produce ductility at room temperature in accordance with my invention varies with the particular material used, but according to my experience heating the metal to or working it at a temperature corresponding to white heat and materially in excess of about 1500° C. will tend to prevent, with any tungsten metal which I have been able to produce, the formation of fiber and will tend to destroy fiber which has been produced by previous working. On the other hand, an excessive amount of mechanical working tends to cause the bodies to become so fibrous and hard as to split up and break. I have found that this result may be obviated by carrying on the mechanical working during the early stages at such temperatures as enable the body to be worked and reduced in size but without causing any special change in the structure of the metal. These temperatures may correspond to a white heat or thereabout but should be above a temperature which I estimate at about 1500 degrees C. At the proper stages of the process the temperature is reduced to 1200 degrees C., or lower, whereupon as the mechanical working progresses the improvement in the structure of the metal begins.

The preparation of a tungsten body which is to be mechanically worked is an important feature of my invention, for it is not every tungsten body which is susceptible of mechanical working. For example, Moissan states (*Comptes Rendus*, vol. 123, pp. 13–16, 1896–7) that he obtained by heating tungstic acid and sugar carbon in a carbon crucible an ingot or melt which presented well fused superficial portions, but which was porous in its interior portions. Of this product Moissan says that when it is in a porous condition it has, like iron, the property that it may be consolidated (*la propriété de se suder à lui-même*), by hammering much below its point of fusion.

Subsequent investigators have expressed the opinion that the material which Moissan

obtained was not pure tungsten, but tungsten contaminated by carbon. Certainly there is no indication that by hammering Moissan was able to do anything more than to close more or less the pores of the porous material, whatever it may have been, to which he refers; nor is there any indication that when he had gone thus far he had produced a material which could be worked.

I have found that in order that the swaging process may be carried on successfully it is necessary that the tungsten should be in a certain physical or molecular condition, such as is brought about by the treatments which I have discussed above. I find it particularly advantageous to work with tungsten powder which is coarse as distinguished from the exceedingly fine and impalpable powder such as has been used in the manufacture of lamp filaments. The operation of heating in the Battersea crucible coarsens the powder, as does also the reduction operation, particularly if it be carried on in the manner described, and if the hydrogen be passed rather slowly through the reduction furnace. While my invention has made it possible with certain precautions to work fine grained metal (especially if it contains oxids, which delay sintering), as by excessively small drafts and by surrounding the rod with a sheath or casing of some other metal, the condition of the tungsten which is characteristic of the coarse powder is one which is peculiarly adapted to the successful practice of my invention.

Though the operativeness of my invention obviously does not depend upon any theory of operation, I may state that I am at present of the opinion that the difficulty which is observed in swaging the rods pressed from the fine powder may well be due to the presence in such rods of certain impurities, probably gaseous impurities, as for example oxygen, which would probably occur as an oxid of tungsten. The atomic weight of tungsten is so high (184) that even a small percentage of oxygen will cause a very large percentage of the tungsten to exist as the oxid. It seems probable that in the sintering process the gaseous impurities are expelled more readily from the rod pressed from coarse powder, while in the case of a rod pressed from fine powder the tendency is to sinter quickly on the outside and so prevent or greatly retard the escape of impurities. This hypothesis is consistent with the fact that the smaller the rod the less the importance of using a specially prepared material.

My opinion that the coarseness of the structure has some effect on the sintering operation is confirmed by the fact that the effects characteristic of coarse grained powder are produced by any process by which a rod is formed which is coarse at the time it is exposed to the sintering operation. For example, I have produced rods from exceedingly fine tungsten powder which, after sintering, swage very well, by carrying on the baking operation in an iron tube furnace. The rods are packed in the tube in powdered silica and hydrogen is passed through the tube. The tube is heated by gas flames for 8 or 10 hours to a rather low temperature. This baking operation produces a rod of coarse grained structure, probably because of the fact that the oxid, naturally existing in considerable quantities in so fine a powder, requires prolonged heating to effect complete reduction and coarsens during this prolonged heating in the oxid stage.

It is desirable in all cases that the sintering operation should take place slowly, in order to give time for the action of the hydrogen to penetrate through the entire mass, and to facilitate the escape of impurities, as well as to prevent the center of the rod, by a too rapid increase of the heating current, from becoming much hotter than the outside and actually melting and running out.

The ultimate temperature reached in the sintering operation should be very high, a dazzling white heat probably not far from 2800° C. It is difficult to give any general rule, except to state that if an insufficiently high temperature is reached the rod will break up in the swaging machine. Such a rod ordinarily shows a very finely grained fracture, while my experience is that the rods which are capable of being worked easily show a somewhat coarser and more crystalline fracture.

It is my belief that certain impurities in the sintered rod, such for example as oxygen and carbon, are highly detrimental and prevent the swaging operation from being successfully carried on. On the other hand I have stated above that certain additions are absorbed from the Hessian or Battersea crucible operation, and I find that these additions do not prevent the swaging while they exercise a highly beneficial action where the tungsten is to be exposed for long periods of time to high temperatures, particularly in the form of incandescent lamp filaments. It may be that "offsetting," a phenomenon which as above explained is characteristic of some drawn wire lamp filaments, is due to the crystallization of the metal and the segregation of impurities, whereby spots are developed at which this side slipping or offsetting occurs, and that the presence of the additions introduced from the Hessian or Battersea crucible retards or interferes with the diffusion of such impurities and thus retards crystallization. It is a fact that this treatment prevents offsetting.

I have succeeded in preventing offsetting in drawn tungsten filaments without using the Battersea crucible process by mixing with the tungsten powder certain refractory materials such as the oxids of thorium, zirconium, yttrium, erbium, didymium, or ytterbium. I have used with especial success thorium nitrate, which gives thoria when decomposed. A small amount of the above mentioned oxids, or of compounds or solutions which upon heating or other treatment will yield these oxids, may be mixed with the tungstic oxid before reduction or with the metal powder after reduction, or may even be introduced after the metal has been made into a stick, either by soaking the stick in a solution of a suitable substance or by heating the stick in the presence of a suitable material in the vaporous condition. When thorium nitrate is used, for example, I employ an amount which is equivalent to 2% or less of thoria referred to tungsten. The essential point seems to be that the material should be introduced before the tungsten is sintered. Such additions, particularly in the case of a filamentary body, may actually produce a certain amount of ductility and flexibility in the sintered filament without mechanical working. Usually, however, instead of directly adding these substances, I prefer to employ the treatment above described of simply firing the tungstic oxid in a Hessian or Battersea crucible, for this treatment is simple, successful and reliable.

While I have referred to a considerable extent to the manufacture of ductile tungsten in which so-called additions are introduced at some stage of the process in order that the resulting product may be especially valuable when used for filaments of incandescent lamps, and in connection with other uses where the metal is to be exposed for long periods of time to high temperatures, nevertheless operative and useful incandescent-lamp filaments may be made by carrying out my process as herein described, omitting the additions whether produced by direct introduction of additional material, as above described, or by the Battersea-crucible process; and where it is sought to obtain ductile tungsten for uses in which it is not likely to be exposed to high temperatures, the introduction of such additional substances may be entirely unnecessary. I do not however wish it to be understood that metal prepared with the additions can only be used in incandescent lamps and for similar purposes, as such metal can, as far as my present knowledge extends, be used for any purpose to which the ductile tungsten prepared without the use of the additions is applicable.

In connection with the swaging operation it should be noted that I have departed radically from the ordinary swaging process, in which the dies are long and the metal is held a considerable time in the machine or passed very slowly through it, so that a number of blows are struck at the same place on the metal, and a smooth surface is produced. I find it highly desirable, particularly in the earlier stages of the swaging process, to use a die with a very short working face such as I have shown in the drawings, and to pass the metal through the machine at high speed and so that it is still highly heated when it emerges from the dies. Indeed, it is best not to allow two successive blows to be struck at too closely overlapping places, because each impact of the die abstracts a certain amount of heat from the material and unless this precaution be observed there is great danger that a blow will be struck upon metal which is too cold to endure it without cracking. Preferably, then, the metal emerges from the swaging machine, not smooth, but showing every distinct blow of the hammer, and therefore with an irregular wavy surface.

The swaging operation, though the most successful at the moment, is not the only operation by which my invention can be practised. For example, I have succeeded, without any swaging operation whatever and using only wire-drawing dies, in producing perfectly ductile tungsten. In this case I have begun the operation with sintered conductors of relatively small size. For example, I have used ordinary sintered series tungsten incandescent lamp filaments of the diameter of 25 mils. Where the original body is so small in diameter it is relatively easy to expel injurious impurities in the sintering process, and the devices above described to facilitate this end, which are of importance in the case of the larger bodies which are required for economical large scale production of lamp filaments, or for the preparation of larger articles, such as X-ray tube targets, projectiles, contacts, etc., become relatively unimportant where the original sintered body is of sufficiently small diameter. I point these filaments by the process of the Whitney Patent, No. 1,008,762, above referred to, and carefully insert the point into a die which is heated to 600 to 650° C. The pointed end is then seized with hot pliers (otherwise it would break) and the filament is then with great care and with a regular steady pull drawn through the die, the diameter of which should be not less than ½ a mil. (.0005 inch less than the maximum diameter of the filament at any point. The filament is then in a similar way drawn through a die having a diameter of ½ a mil. (.0005 inch) less than that of the first die, and so on down to 13 mils. Below this size the dies should vary in steps of one-quarter of a mil. until a size of say four mils. is

reached when the dies should then vary by one-eighth of a mil. or less. As the wire becomes smaller the temperature of drawing is reduced; at 18 mils. or thereabout the temperature is reduced from 600 or 650° to 500° C; at 10 mils. the temperature is reduced to 400° C. The dies are lubricated with aqua dag or oil dag, as in the wire-drawing process first described. After such a 25 mil. filament has been drawn to a diameter of 7 mils., it can, at room temperature, be bent around the finger without breaking, and will readily take a permanent set. As the tungsten is still further worked by drawing down to smaller sizes, the fibrous condition becomes more and more developed and the wire becomes more and more pliable, until, at a diameter of about 4 mils., it is in every sense ductile material, and could if desired be manipulated as any other ductile metal, and drawn through dies not heated above room temperature, though I ordinarily heat the dies during the last stages of the drawing process as well as during the first stages, since by the application of heat the drawing is rendered somewhat easier.

As a convenient means for keeping the tungsten hot during the drawing operation, I may, if desired, pass current through the material under treatment. The die and the portion of the wire which is hot may be inclosed in an evacuated space or in a hydrogen or other reducing atmosphere, although I do not find it necessary to do so. The lubricants mentioned herein themselves materially assist in protecting the wire from oxidation. So also I have succeeded in producing ductile tungsten by a rolling process. In carrying out such a process, at least until the metal has acquired a considerable amount of fiber, the rolling operation should be carried on with the metal at a high temperature, preferably between what is known as "bright red heat" and "white heat," and that the metal should retain this temperature as long as the rolls are acting upon it. Excessive temperatures, such as temperatures above 1500° C., are objectionable for the reasons and to the extent already explained. The rolls naturally abstract heat rapidly and therefore the metal should pass through the rolls at very high speed; it is also essential that the draft of the rolls should not be too great. Also, at least during the later stages of rolling, the temperature should not be higher than about 1200° C.; and preferably in the neighborhood of 1000° C. When a sufficiently fibrous condition has been obtained by rolling, the metal may be run through dies as above described, or the working may be continued exclusively by rolling.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. The process of producing tungsten having a fibrous structure which consists in repeatedly hot working a crystalline body of tungsten until the crystalline structure is broken down and a fibrous structure developed.

2. The process which consists in agglomerating tungsten powder, sintering the body thus formed, subjecting it to repeated hot working, and continuing such hot working until the body remains ductile when cold.

3. The process of producing ductile tungsten wire which consists in forming a sintered body of tungsten, hot swaging said body repeatedly until it becomes fibrous in structure, and then further reducing it by hot drawing.

4. The process of producing ductile tungsten wire, which consists in first forming a sintered body of tungsten free from oxygen carbon and other impurities which would render the body unworkable mechanically, then hot swaging such sintered and purified body repeatedly until it becomes fibrous in structure and then further reducing it by hot drawing.

5. The process which consists in mechanically working while hot tungsten which is brittle at room temperature until it becomes pliable at room temperature.

6. The process of forming bodies of coherent homogeneous tungsten which consists in agglomerating tungsten powder, sintering the body thus formed, and then subjecting it to hot mechanical working to such an extent as to improve the internal structure and to bring the body into a shape adapted for use in the arts.

7. The method which consists in first producing a body of tungsten sintered or compacted throughout and free from such impurities as would render the body unworkable mechanically, and then hot working said body to such an extent as to deform its crystalline structure and to bring it into a shape adapted for use in the arts.

8. The method of producing pliable tungsten wire for lamp filaments, which consists in first producing a body of tungsten in a sintered state and free from oxygen carbon and other impurities which would render the body unworkable mechanically and then subjecting this sintered and purified body to mechanical working many times repeated, with gradual reduction in diameter and elongation in length.

9. The method which consists in agglomerating relatively coarse tungsten powder into a porous mass, eliminating harmful impurities and compacting the mass by a sintering operation, and then mechanically working the resulting body while hot into the desired shape.

10. The method of producing ductile tungsten which consists in sintering an agglomerated mass of tungsten particles or

powder into a dense coherent and homogeneous form in such manner as to allow elimination of harmful impurities, and then mechanically working said body until it is brought into the desired condition.

11. The process which consists in agglomerating tungsten powder, treating the body thus formed so as to eliminate any oxygen present therein and to produce therefrom a sintered body, and then hot working such sintered body.

12. The process which consists in reducing tungsten oxid to coarse tungsten powder, agglomerating said powder into a coherent porous body, heating said body to drive out impurities and sinter the body, and then subjecting the body to hot mechanical working.

13. The process which consists in firing tungsten oxid in a refractory crucible of the Hessian or Battersea type, reducing the oxid to coarse metallic powder, agglomerating the powder into a coherent body, sintering the body, and then subjecting it to hot mechanical working.

14. The process which consists in forming a body of tungsten powder containing additional material which will prevent coarse crystallization of the tungsten at high temperature, sintering the body, and then subjecting it to hot mechanical working.

15. The step in the preparation of tungsten bodies which consists in firing tungsten oxid in a refractory crucible of the Hessian or Battersea type, and subsequently reducing the oxid to metallic tungsten powder.

16. The process which consists in producing tungsten containing beneficial additions, forming it into a billet, sintering it at high temperature, and mechanically working it a great number of times at high temperature, and reducing the temperature during the working.

17. The method of producing bodies of tungsten pliable and ductile at ordinary or room temperatures from bodies of tungsten which are brittle at ordinary or room temperatures, which consists in heating said brittle bodies to a temperature sufficient to render them susceptible of mechanical working, repeatedly working the bodies while so heated, and during at least the last stages of mechanical working carrying on the working at temperatures such that the mechanical working has the effect of producing ductility in the finished product.

18. The method of producing bodies of ductile tungsten from bodies of tungsten which are non-ductile, which consists in mechanically working the non-ductile bodies of tungsten within a temperature range at the lower limit of which the body to be worked is soft enough to be susceptible of such working while the upper limit, at least during the later stages of the working, is sufficiently low to cause the body thus worked to retain to a greater or less degree the effect of the mechanical working.

19. The method of producing ductile tungsten which consists in repeatedly hot working a tungsten body within a range of temperature in which the body is sufficiently soft to be susceptible of such working, but maintaining the temperatures below those at which the effect of the mechanical working is lost.

20. The method of producing a body of ductile tungsten from a body of tungsten which is brittle when cold, which consists in mechanically working said body while heated to a temperature at which the body is softened and finishing the mechanical working at temperatures below those at which no ductility is imparted to the metal by the mechanical working.

21. The method which consists in mechanically working at a temperature above approximately 1500 degrees C. a tungsten body which is brittle cold, interrupting the operation before the body is brought into the form ultimately desired, and completing the mechanical working at a temperature below 1500 degrees C.

22. The method of securing a ductile metal body without previous melting of the metal, which consists in producing a compact body of metal from divided metalliferous material, consolidating said body by heating to a temperature less than the melting temperature and such as to produce a body of metal non-ductile when cold, subjecting the body to repeated mechanical working while in a heated condition, and continuing the working until the body is ductile without the application of heat.

23. The method of securing a ductile metal body without previous melting of the metal, which consists in producing from divided metalliferous material a compact body of metal, sintering said body and thereby producing a crystalline body brittle at room temperatures, and then subjecting the body to repeated mechanical working while hot, and continuing the working until the metal remains ductile when cooled.

24. A wire formed of ductile tungsten.

25. An incandescent electric lamp having a filament of drawn tungsten wire.

26. Substantially pure tungsten having ductility and high tensile strength.

27. A ductile tungsten wire having a fibrous structure.

28. A form of tungsten metal pliable at room temperature.

29. An incandescent electric lamp having a filament formed of ductile tungsten.

30. A lamp filament of tungsten which

resists offsetting and has high tensile strength.

31. A filamentary conductor of drawn tungsten so constituted as to be free from offsetting when operated as a filament of an incandescent lamp.

32. A filament for electric incandescent lamps consisting of tungsten wire which is pliable at ordinary or room temperature.

33. The material wrought tungsten, having a specific gravity of approximately 19 or greater, and capable of being forged and worked.

34. Wrought tungsten, a solid coherent material characterized by the presence of crystals deformed by mechanical working.

In witness whereof, I have hereunto set my hand this 18th day of June, 1912.

WILLIAM D. COOLIDGE.

Witnesses:

NEWTON A. BURGESS,

HELEN ORFORD.

DISCLAIMER.

1,082,933.—*William D. Coolidge*, Schenectady, N. Y. TUNGSTEN AND METHODS OF MAKING THE SAME FOR USE AS FILAMENTS OF INCANDESCENT ELECTRIC LAMPS AND FOR OTHER PURPOSES. Patent dated December 30, 1913. Disclaimer filed January 25, 1929, by the assignee, *General Electric Company*.

Hereby disclaims the subject matter of claims 14, 16, 24, 25, 26, 28, 29, 30, 31, 32, and 33.

Your petitioner further hereby disclaims the subject matter of claim 27, which reads as follows:

"A ductile tungsten wire having a fibrous structure." except when the product defined in said claim 27 has been produced by the process disclosed in the specification of said patent, as more particularly defined in claim 5 of the said patent.

[*Official Gazette February 5, 1929.*]

[fols. 364-365] PLAINTIFF'S EXHIBIT No. 14

UNITED STATES PATENT OFFICE.

RALPH E. MYERS AND ROY D. HALL, OF EAST ORANGE, NEW JERSEY, ASSIGNORS TO WESTINGHOUSE LAMP COMPANY, A CORPORATION OF PENNSYLVANIA.

FILAMENT FOR INCANDESCENT ELECTRIC LAMPS.

1,363,162. Specification of Letters Patent. Patented Dec. 21, 1920.

No Drawing. Application filed May 14, 1915. Serial No. 28,163.

To all whom it may concern:

Be it known that we, RALPH E. MYERS, a citizen of the United States, and a resident of East Orange, in the county of Essex and State of New Jersey, and ROY D. HALL, a citizen of the United States, and a resident of East Orange, in the county of Essex and State of New Jersey, have invented a new and useful Improvement in Filaments for Incandescent Electric Lamps, of which the following is a specification.

Our invention relates to the manufacture of filamentary material, and it has special reference to such filaments as constitute incandescent bodies for electric lamps.

The object of our invention is to provide filaments of the above-indicated character which shall possess good electrical properties and which shall likewise be durable and resistant to mechanical shocks and to structural changes resulting from the passage of electric current through the filaments.

More particularly, the object of our invention is to provide metallic filaments, composed largely or mainly of metals of the tungsten type, which shall be highly resistant to the structural alterations known as "offsetting" or "faulting" that tend to develop in this class of filaments during their use.

Certain materials which are suitable for use as filaments for incandescent electric lamps have considerable mechanical strength when first formed into filaments but become exceedingly fragile after they have been traversed by electric currents. This phenomenon is a characteristic of tungsten filaments, whether such filaments are prepared by squirting or drawing processes, and it is found that pure tungsten filaments which have considerable initial strength and which, in the case of drawn tungsten wire, may even have a tensile strength many times exceeding that of steel, become brittle after being traversed by current for a few hundred hours. The filaments are therefore easily broken and, upon microscopic examination, they are found to have undergone marked structural alterations. The outline of such a filament shows lateral displacement of sections of the filament relative to one another, and this displaced condition, which is known in the art as "offsetting" or "faulting," appears to be caused by the development and growth of crystals within the body of the filament. Such crystals seem to increase in size in much the same manner as crystals formed in liquid solutions, and, if the crystals become large enough to extend almost or entirely across the filament, adjacent crystals tend to slip along their cleavage planes, thereby giving the filament the offset of faulted appearance above referred to. It therefore appears that internal crystallization produces offsetting and that offsetting imparts brittleness to the filaments.

The phenomenon described above becomes a particularly serious problem in the manufacture of slender metallic filaments which are used in the smaller types of incadescent lamps such as 25-watt, 40-watt and similar lamps.

An efficient method of resisting offsetting in lamp filaments was proposed by Dr. Anton Lederer and described in United States Patent, #1,180,264 and assigned to the Westinghouse Lamp Company.

According to Dr. Lederer's method, and according to the technical practice heretofore prevailing, the preferred addition materials are the oxids of the rear earth metals, particularly thorium oxid.

We have discovered that the offsetting of lamp filaments may be effectively prevented by the addition of small amounts of other refractory substances which neither volatilize nor decompose under the conditions existing in glowing incandescent filaments. The substances which we have discovered to be particularly suitable for this purpose are the oxids of the alkali metals, the alkaline earths, and also certain oxids belonging to neither of these classes, such as beryllium oxid, aluminum oxid and titanium oxid, TiO_2. For the present purpose, we include magnesium oxid among the alkaline earths, as well as calcium oxid, barium oxid and strontium oxid. Of the alkali metal oxids, we have found lithium oxid to be particularly effective, and of the alkaline earth oxids, calcium oxid and magnesium oxid are especially suited to our purpose.

We have found also that excellent results may be obtained by the use of mixtures of two or more of the substances enumerated above, or mixtures of one or more of these substances with one or more oxids of rare earth metals, including thorium oxid. Very

satisfactory results have been obtained by using calcium oxid and magnesium oxid as the additive materials. Such mixtures give superior results in some cases, although the reason why such improved results are obtained with mixtures is not clear.

Our invention is of special importance in the manufacture of tungsten filaments, but it may also be applied to filaments composed of other metals, such as molybdenum, tantalum and the like.

Very small amounts of offset-resisting materials are sufficient to greatly retard the development of offsetting. A few hundredths of one per cent. are sometimes sufficient, and it is usually unnecessary to add to the filaments more than 5% of their weight of the offset-resisting additions in order to obtain the maximum offset-resisting effect.

The addition of the offset-resisting materials may be made at any desired stage of the manufacture of the filaments, but in making drawn tungsten filaments, we ordinarily find it convenient to add the offset-resisting materials to the powdered oxid before it is reduced to metal. The precise steps of the process of forming filaments by drawing, squirting or otherwise form no part of our present invention. It is also to be understood that other limitations are not to be imposed thereon except as indicated in the appended claims.

We claim as our invention:

1. A filament comprising drawn tungsten wire that tends to offset when utilized as a conductor of electricity and also containing calcium oxid and magnesium oxid.

2. A filament comprising tungsten that tends to offset when utilized as a conductor of electricity and also containing at least two of a group of substances including the alkali metal oxids, the alkaline earths, beryllium oxid, aluminum oxid, and titanium dioxid.

In testimony whereof we have hereunto subscribed our name this 30th day of April, 1915.

RALPH E. MYERS.
ROY D. HALL.

Witnesses:
ALFRED H. EDGERLEY,
FREDERICK A. BETTS.

[fols. 366-370] DEFENDANTS' EXHIBIT A

UNITED STATES PATENT OFFICE.

ALADAR PACZ, OF CLEVELAND, OHIO, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

METAL AND ITS MANUFACTURE.

1,299,017. Specification of Letters Patent. Patented Apr. 1, 1919.

No Drawing. Application filed May 25, 1914. Serial No. 840,721.

To all whom it may concern:

Be it known that I, ALADAR PACZ, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga, State of Ohio, have invented certain new and useful Improvements in Metals and Their Manufacture, of which the following is a specification.

My invention relates to metals in general and to the processes of their manufacture. The object of my invention, stated generally, is to improve the said processes of manufacture so as to produce metals having properties which will render them more durable and, in this and other respects, more suitable for use in the arts.

In its more specific aspect, my invention is applicable to metals which are produced by mechanically working an agglomeration of finely divided metals. An example of such a metal is tungsten, which is produced in a wrought and drawn state by the process described in Coolidge Patent No. 1,082,933, issued December 30, 1913.

One of the main difficulties which is met with in the case of metals in general is that, when subjected to the severe stresses incident to their use in the arts, they lose to a large extent the characteristics which they originally possessed. This is particularly true of metals which are subjected to heating at a high temperature, as by heating to incandescence. Under such conditions, as a rule, metal bodies lose their pliability and, moreover, tend to lose their original form or shapes. Another difficulty is that high heating or other stress causes the metal to crack. In the case of wrought or drawn tungsten which is made into filaments for incandescent lamps, this failure to retain its original properties is quite striking. Although the said metal is pliable and will take a set as originally made, after its use in the incandescent lamp it becomes quite brittle and sags, losing its original shape. Moreover, unless means are taken to lessen the tendency to crack, cracking will occur and produce the condition known as offsetting. Offsetting is a lateral shifting of one section of filament with respect to the adjacent section. There are methods in use for preventing offsetting. These are described in the aforesaid Coolidge patent, and also in Frech Patent No. 1,089,757, March 10, 1914. In a general way these methods are similar in that they consist in incorporating with the tungsten or rather the oxid from which the tungsten is derived, certain foreign materials such as those obtained by firing the tungstic oxid in a Battersea or Hessian crucible, or by firing it with a compound of thorium. Although these methods have proven efficacious, they have the disadvantage that the introduction of foreign material of this kind into the filament is apt to have deleterious effects. Although at present these deleterious effects can not be definitely stated, it is obvious that the fewer the materials entering into the composition of the filament the more easily can uniformity in the final product be secured. The advantage of uniformity in a product of such great output as the incandescent lamp will be obvious. The necessity of rapid manufacture renders desirable a minimum of steps and, therefore, of materials added in the manufacturing process.

The object of my invention is to produce a metal which will possess in a much higher degree than any metal of the same name heretofore produced, the characteristic of retaining its original properties when subjected to severe physical stresses. I attain this object without adulterating the metal. My invention as hereinbefore stated, is particularly applicable to metals produced by agglomerating finely divided metal and then working it into wrought or drawn form. The metal produced by the process described in the Coolidge patent heretofore referred to, and at present used in the manufacture of filaments for incandescent lamps, runs 99.2% or below pure metal. On the other hand, the metal comprised by my invention runs above 99.2% pure metal. I have produced metals having the desirable properties hereinbefore described which ran from 99.7% to 99.95% pure tungsten. These metals were pliable and showed no offsetting after continued use as filaments in incandescent lamps. Moreover, coiled filaments made from these metals retained their shape to a very high degree after continued use.

The novel portion of the process com-

prised by my invention is applied to the production of the original metal and prior to any working of the same. In the case of metals produced from an agglomeration of fine metals, it is applied to the production of the constituent fine metals and their agglomeration. In the case of tungsten and similar metals the remainder of the process, namely, the working of the metal, is similar to the corresponding portion of the process described in the Coolidge patent hereinbefore referred to. I have discovered that, instead of forming the slug by agglomerating a simple, finely divided metal, greatly superior results are secured by forming the same of two or more metals having substantially the same chemical composition but differing in certain respects in physical characteristics. It is not sufficient that the differences in the physical characteristics of the constituent metals reside in the shape or size of the discrete particles thereof. My theory is that these differences in the metals have their origin in differences in the molecular structure. Although disclaiming any intention to limit myself to any particular theory, I will use the term "molecular" to define the differences which I consider must be present in order to secure the desired results, and by this term I mean such differences as are ulterior to those of mere shape or size of particles.

Various methods may be adopted to secure the desired differences in the molecular structure of these finely divided metals. The method to which I attach the greatest importance is the variation of the base of the compound from which the metal is ultimately derived. Another method is to form by polymerization various compounds having the same base and to derive the metal from each. This may be done by the addition of chemical compounds in certain ways or by heating or by the combination of these methods. Perhaps the best results are secured by the combination of all of these methods. However, the same general principle applies to all of them and it is obvious that the desired effect may be secured by one of them alone if applied to the proper degree.

As a demonstration of the efficacy of the first of the methods above referred to, I have obtained several varieties of finely divided tungsten by varying the base of the compound from which the tungsten was derived. By treating commercial tungstic oxid with compounds of lithium, ammonium, sodium, and potassium, respectively, and deriving the finely divided tungsten from the compound of tungsten formed in this way in each case, I found that the samples differed considerably in physical characteristics. For instance, the order of blackness of the metal was the same as that of the atomic weight of the base. In other words, the higher the atomic weight of the base, the blacker the finely divided metal. This was also true of the order of density. On the other hand, the order of electrical conductivity was inverse to that of the atomic weight. It is probable that the metals thus produced are allotropic forms of tungsten. However, I do not wish to be limited by the accepted meaning of this term. The fact is that the ultimate metals had practically the same chemical composition but had the above stated differences in physical characteristics. As uniformity was preserved in the derivation of the metals, except as to the base of the compounds from which the metals were derived, it is logical to attribute the aforesaid differences to the use of different bases. Owing to the fact that the above stated differences are not such as depend merely upon the size or shape of the particles, I consider that they reside in the molecular structure of the metal, using the term "molecular" in the sense hereinbefore defined.

I will now give a specific example of my invention as applied to the production of tungsten. A mixture is made of tungstic oxid 1400 grams, potassium carbonate 620 grams, sodium carbonate 620 grams, sodium nitrate 150 grams, and potassium nitrate 150 grams. These ingredients are mixed with a sufficient amount of water to make a thick paste. This paste is then poured upon a sheet iron plate and heated to a temperature of about 500 degrees to 600 degrees C. and allowed to dry to form a cake. The action of the heat upon this cake softens it somewhat and it is worked with an iron spatula for half an hour or more until the green color which it has at first disappears. The material is then heaped in a pile on an iron plate and heated at about 900 degrees C. by a gas flame played directly upon it. This is continued for about fifteen minutes. During this operation the mass shrinks in volume and a part of the carbon dioxid is driven off. After this, the material is dissolved in about six liters of water and the solution filtered. Tungstic oxid is then precipitated by means of hydrochloric acid. The tungstic oxid so obtained is then dissolved in aqueous ammonia, one cubic centimeter of ordinary concentrated ammonia being used to one gram of tungstic oxid, and such amount of water being added that the resulting solution will contain 300 grams of tungstic oxid per liter. The solution is then divided into two parts. From one part ammonium tungstate crystals are formed, either by adding concentrated hydrochloric acid to the point of neutralization or by playing a gas flame directly upon the solution. I prefer the latter method. The crystals so obtained are then dried and ignited at a temperature of about 450 degrees

C. to produce tungstic oxid. From the other part of the solution tungstic oxid is reprecipitated by means of hydrochloric acid. The tungstic oxids thus obtained are mixed and reduced to tungsten powder which may be worked into wire in the manner disclosed in the Coolidge patent hereinbefore referred to.

Although the tungstic oxids produced from each half of the solution, as above described, are of the same chemical formula, their physical characteristics are different. I consider that the tungstic oxid obtained from the crystals of ammonium tungstate has characteristics corresponding to potassium, while the tungstic oxid obtained from the other half of the solution has characteristics corresponding to ammonium. According to my theory, the potassium being more electropositive than the sodium, gives the character to the tungstic oxid in the first fusion. The tungstic oxid precipitated by means of hydrochloric acid still retains this influence, as subsequent dissolving in ammonia and crystallization do not destroy it. However, in the case of the other half of the solution the reprecipitation of the tungstic oxid by means of hydrochloric acid destroys the potassium characteristic and gives the tungstic oxid thus produced the ammonium characteristic. For convenience in designating these varieties of tungstic oxids, I apply to them the numeral corresponding to the atomic weight of the element or radical whose characteristic they possess. Consequently, the lithium tungstic acid would be known as 7, the ammonium as 18, the sodium as 23, the potassium as 39, and so on. In the specific process above described the tungstic oxid derived from the crystals would be known as 39 tungstic oxid, while that derived by reprecipitation would be known as 18 tungstic oxid. Although good results may be obtained by mixing various kinds of these tungstic oxids, I have obtained the best results by including in each mixture with one or more of the other kinds at least a small portion of the 39 tungstic oxid.

In connection with the reprecipitation by means of hydrochloric acid of the tungstic oxid from one portion of the ammonium tungstate solution I have found that exceptionally good results are secured in the following manner: The hydrochloric acid is added gradually until neutralization of the solution is secured. At this point various ammonium tungstate and probably meta-tungstate and poly-tungstate crystals are formed. The whole solution and crystals contained therein is then poured into hot hydrochloric acid and the tungstic oxid is thrown down. The good results thus obtained I attribute to the fact that the tungstic oxids obtained from the polymers of ammonium tungstate have different molecular structure and properties. It is to be noted also that the original fusion of the material with the nitrate present would have the effect of producing polymers to a certain extent.

I have found that to obtain the best results care should be taken to conduct the heating of the mixed tungstic oxids under proper conditions. The amount of the material and the thickness of the layer which is being heated, the temperature of heat, the pressure applied to the materials, the fineness of the material and the duration of heating all seem to affect the result.

In mixing and reducing the oxids, in one case which gave very good results, I adopted the following procedure. I made up six batches of tungstic oxid, the first batch being 140 grams 39 and 10 grams 18; the second 130 grams 39 and 20 grams 18; the third 120 grams 39 and 30 grams 18; the fourth 110 grams 39 and 40 grams 18; the fifth 100 grams 39 and 50 grams 18; and the sixth 90 grams 39 and 60 grams 18. In each case the materials were mixed thoroughly, put in boats and compressed by the application of about 700 pounds. Each was then shoved through an electric tube furnace, about two feet long, at a uniform rate, so that it took about ten minutes for each of them to pass through the furnace. The temperature maintained was between 900 and 1100 degrees C. The resulting material was then powdered up and all of the batches mixed, after which the tungstic oxid was reduced, by means of hydrogen, to tungsten powder, the heat being about 900 degrees C. An analysis of the metal thus produced showed that it ran about 99.9% tungsten. Filaments produced from this metal were much superior to those heretofore produced. Not only was offsetting practically eliminated, but the wire was much more pliable after continued burning. One test applied which demonstrated the superiority of the metal as to pliability was to run it at an efficiency of .8 watts per candlepower for a period of 120 hours. Under the same conditions the filaments heretofore produced become brittle. The metal produced by my process was still quite pliable and possessed considerable tensile strength. When subjected to a test in which a knife edge was pressed against the filament so as to crimp it at a number of uniformly spaced points, the filament produced by my process showed 100 per cent. pliability, while the other metal was broken up into small pieces. My wire also showed no tendency to offset. I have found that a test which may be applied to wire which will show whether it will offset in the lamp is to give it what is known as the cross-section test. For this test a rod of a metal of 80 mils in diameter is heated for 8 minutes in hydrogen at a temperature close to the

melting point of tungsten. The rod is then fractured and the cross-section examined. If the cross-section is shiny or shows coarse grains, the filament will offset. On the other hand, if the structure is finely granular, the filament will not offset. Rods produced from the metal, as above described, when subjected to this test had cross-sections which were finely granular.

It is to be understood that other methods of obtaining the requisite variety of the molecular and physical characteristics of the constituent metals will readily suggest themselves to those skilled in the art. Although I have given a specific example of my method as applied to tungsten, it is obvious that in case of other metals variations may be made to suit the particular metal which is to be produced. All of such variations are to be considered as coming within the scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. An agglomeration for use in the manufacture of tungsten bodies consisting of a mixture of substantially pure tungstens derived from different chemical compounds of tungsten.

2. An agglomeration for use in the manufacture of tungsten filaments for incandescent lamps consisting of a mixture of substantially pure tungstens derived from different chemical compounds of tungsten.

3. The process of producing tungsten and like metal bodies having the property of retaining to a high degree their original characteristics when subjected to severe physical stresses which consists in agglomerating metals of substantially the same chemical composition but differing in molecular physical characteristics and then mechanically working the bodies so formed.

4. The step in the production of tungsten and like metal bodies having the property of retaining to a high degree their original characteristics when subjected to severe physical stresses which consists in mixing together metals having substantially the same chemical composition but differing in their mode of preparation so that they have different molecular structures.

5. The step in the process of producing tungsten and like metal bodies having the property of retaining to a high degree their original characteristics when subjected to severe physical stresses which consists in mixing together metals having substantially the same chemical composition but differing in respect to the chemical compounds from which they are derived.

6. The process of producing tungsten and like metal bodies for use as filaments in incandescent lamps having the property of retaining to a high degee their original characteristics when subjected to severe physical stresses which consists in agglomerating finely divided metals of substantially the same chemical composition but differing in their molecular physical characteristics and then mechanically working the body so formed.

7. The step in the production of tungsten and like metal bodies for use as filaments in incandescent lamps having the property of retaining to a high degree their original characteristics when subjected to severe physical stresses which consists in mixing together metals having substantially the same chemical composition but differing in their mode of preparation so that they have different molecular structure.

8. The step in the process of producing tungsten and like metal bodies for use as filaments in incandescent lamps having the property of retaining to a high degree their original characteristics when subjected to severe physical stresses which consists in mixing together metals having substantially the same chemical composition but differing in respect to the chemical compounds from which they are derived.

9. The step in the process of producing tungsten which consists in mixing together tungsten powders of substantially the same purity but derived from different chemical compounds of tungsten.

10. The step in the process of producing tungsten which consists in mixing together tungsten powders of substantially the same purity but derived from chemical compounds of tungsten having different bases.

11. The process of producing tungsten which consists in mixing together tungsten powders of substantially the same purity but derived from different chemical compounds of tungsten, agglomerating the mixture and mechanically working the body so produced.

12. The process of producing tungsten which consists in mixing together tungsten powders of substantially the same purity but derived from chemical compounds of tungsten having different bases, agglomerating the mixture and mechanically working the body so produced.

13. A tungsten body substantially free from offsetting after continued subjection to temperatures attained by filaments in electric incandescent lamps and containing substantially no non-metallic material or other metal.

14. A tungsten filament substantially free from offsetting after continued use in an electric incandescent lamp and containing substantially no non-metallic material or other metal.

15. A drawn tungsten body substantially free from offsetting after continued subjection to temperatures attained by filaments in

electric incandescent lamps and containing substantially no non-metallic material or other metal.

16. A drawn tungsten filament substantially free from offsetting after continued use in an electric incandescent lamp and containing substantially no non-metallic material or other metal.

17. An electric incandescent lamp composed of tungsten containing substantially no non-metallic material or other metal, and capable of continued use without becoming substantially brittle.

In witness whereof, I have hereunto set my hand this 21st day of May, 1914.

ALADAR PACZ.

Witnesses:
PAUL P. BACHMANN,
JOHN H. ANDERSON.

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[fols. 371-377] DEFENDANTS' EXHIBIT B

272

I. LANGMUIR.
INCANDESCENT ELECTRIC LAMP.
APPLICATION FILED APR. 19, 1913.

1,180,159.

Patented Apr. 18, 1916.
2 SHEETS—SHEET 1.

Fig. 1.

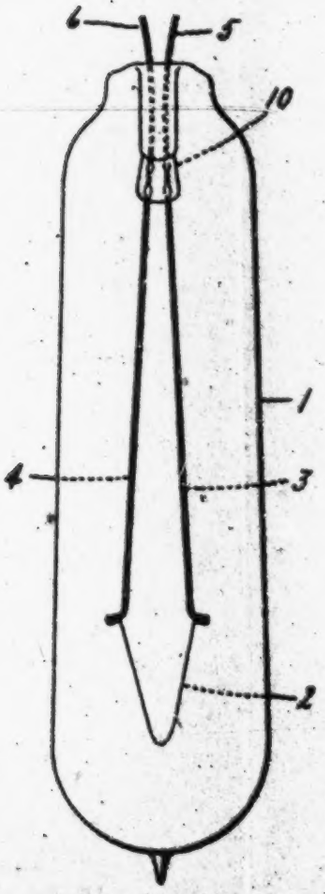
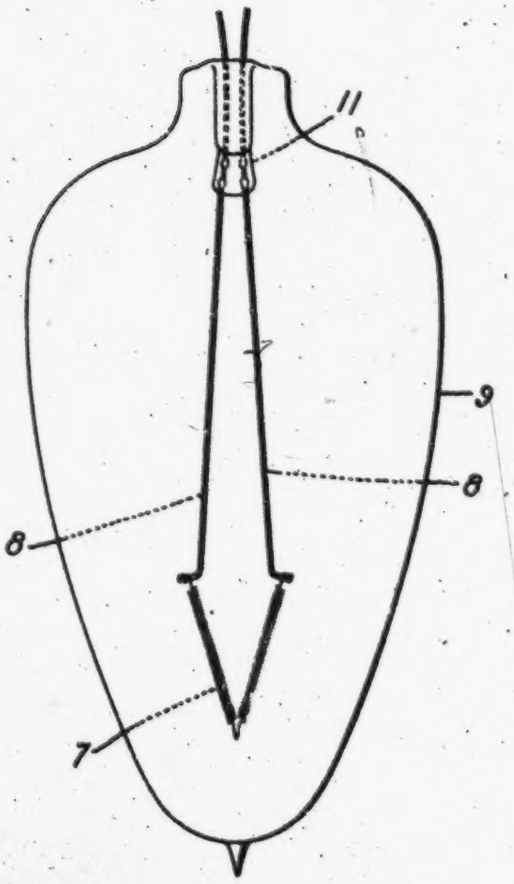


Fig. 2.



Witnesses:
George H. Fildew
J. Ellis Glen

Inventor:
Irving Langmuir,
by Albert G. Davis
His Attorney.

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273

I. LANGMUIR.
INCANDESCENT ELECTRIC LAMP.
APPLICATION FILED APR. 19, 1913.

1,180,159.

Patented Apr. 18, 1916.
2 SHEETS—SHEET 2.

Fig. 3.

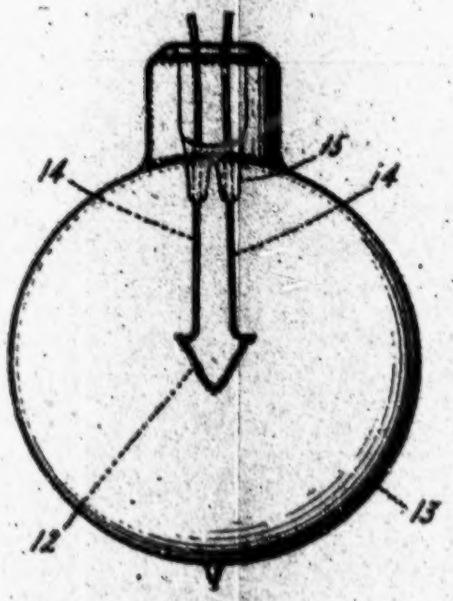


Fig. 4.

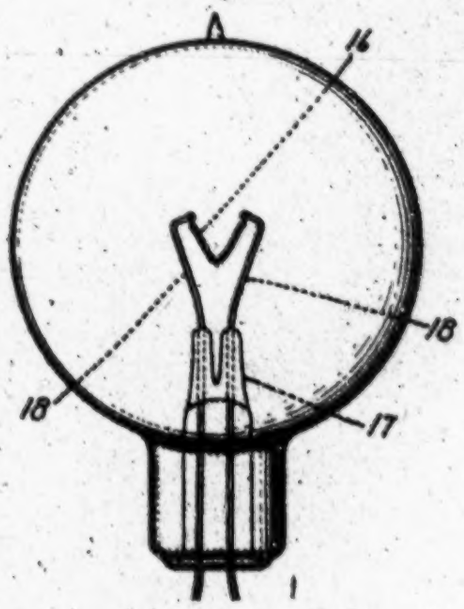
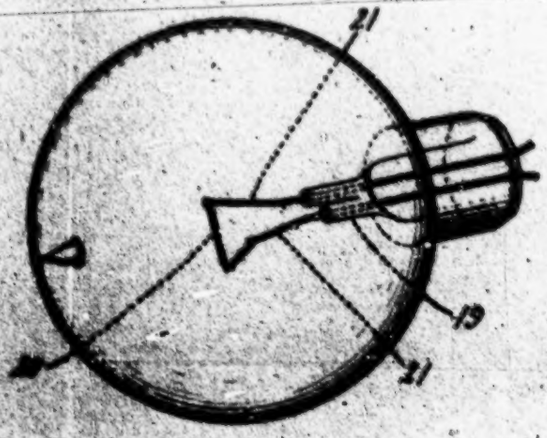


Fig. 5.



Witnesses:
George H. Fisher
J. Ellis Glen

Inventor:
Irving Langmuir,
by Albert G. Davis
His Attorney.

UNITED STATES PATENT OFFICE.

IRVING LANGMUIR, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

INCANDESCENT ELECTRIC LAMP.

1,180,159. Specification of Letters Patent. Patented Apr. 18, 1916.

Application filed April 19, 1913. Serial No. 762,337.

To all whom it may concern:

Be it known that I, IRVING LANGMUIR, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Incandescent Electric Lamps, of which the following is a specification.

My present invention relates to improvements in incandescent electric lamps whereby it is possible to produce a lamp capable of operating at extraordinarily high efficiency and giving a light of marked increase in intrinsic brightness and whiteness, as will be more fully hereinafter set forth.

In the drawings attached to this specification, Figure 1 is a view of a lamp embodying my invention, while Figs. 2, 3, 4 and 5 show modifications within the scope of my invention.

I will now proceed to describe in detail the lamp shown in Fig. 1, which represents one particular type of lamp embodying my invention.

1 is the lamp bulb, which is decidedly elongated; 2 is a filament of tungsten which may be constructed by any of the now well-known squirting or drawing processes. In this case the filament is about 10 mils in diameter and about three inches long. The filament is located near the bottom of the bulb and is supported by heavy, stiff, wrought tungsten wires 3, 4, connected through conductors 5 and 6 with the external terminals. The lamp bulb is filled with nitrogen carefully purified and free from water-vapor, admitted at a pressure which may be as low as say 50 mm. but which to advantage may be atmospheric when the lamp is cool. The bulb is finally sealed in the usual manner.

In the manufacture of the lamp I dry the gas by carrying it a number of times over phosphorous pentoxid, and further I thoroughly dry the bulb of the lamp and free it from adhering gases and water vapor by exhausting for a long time while it is heated in a suitable oven to a temperature as high as can practically be realized without danger of unduly softening the glass, and do not admit the dry nitrogen until I have in this way removed from the glass as far as possible all traces of water vapor.

The particular lamp shown is adapted to operate at a current of about 8 amperes with an efficiency of about .7 to .8 watts per candle. At this efficiency the lamp has substantially the commercial useful life of standard lamps on the market at the present time, the drawn-wire tungsten lamps, which with a corresponding life have an efficiency of about 1 to 1¼ watts per candle.

The efficiency of an incandescent lamp of a given type and construction is in general directly related to its useful life, that is to say, a lamp which will operate at 1¼ watts per candle for 1,000 hours useful life can be run at one watt per candle by simply increasing the voltage to which it is subjected, but the useful life will be much shortened, and the same lamp set up at .5 watts per candle will be blackened and destroyed in a few minutes.

It is not new in the art to use an incandescent lamp filament of tungsten, as such filaments are well known and in common use on a large scale. It has been suggested in the past to introduce into a lamp bulb a neutral atmosphere at a fairly high pressure, but I am not aware that any such lamps have ever been used commercially or have been technically successful.

It was at one time proposed to introduce nitrogen into the bulb of a lamp having a carbon filament, and, in order to reduce the convection losses, that the filament should be reduced to "a smaller cross section than usual heretofore." The lamp was a failure for reasons which, in the light of the work which I have done, can readily be pointed out. In the first place, as will appear more fully hereafter, the reduction of the cross section of the filament was a step decidedly in the wrong direction, but also very serious is the chemical action between the nitrogen and the carbon of the filament, which at the temperature of incandescence react on each other to form cyanogen, and ultimately para-cyanogen. This action not

only obscures the bulb by a deposit of a brown powder of para-cyanogen, but also destroys the filament. It was also proposed to use cyanogen in place of nitrogen, but this combination also is inoperative since the cyanogen decomposes and deposits carbon on the filament, so that the size of the filament continually increases and its resistance continually decreases, and if the lamp be placed in multiple across the mains so that it is supplied with constant potential, the action is a cumulative one, the lamp "runs away," that is to say, the filament grows in size and temperature until in a few minutes it is destroyed, while if on the other hand it is operated in series on a constant current circuit, its reduced resistance reduces its temperature and its efficiency is lost.

My experience has shown that it is necessary that certain relations exist between the atmosphere of the lamp and the material of the filament. The combination which I have found to be most suitable is the one above described. Tungsten possesses a great advantage over carbon which renders it highly suitable for use in my improved lamp, in that it has not only a high melting point but also a very low vapor pressure at high temperatures. The light emission from a lamp is in proportion to the eleventh power of the absolute temperature, so that a very slight increase of temperature above that normally used in incandescent lamps brings about a very considerable increase in efficiency. This increase is sufficiently great in lamps constructed in accordance with my invention to produce the striking results above described, in spite of the fact that a certain amount of heat is wasted by convection; but carbon in an atmosphere of nitrogen or cyanogen, irrespective of the vital difficulties, above mentioned, has the property of slowly vaporizing at temperatures corresponding to three watts per candle, and a very slight increase of temperature causes a considerable increase in the rate of vaporization; so that a carbon lamp operated either in a vacuum or in the manner described by Edison becomes blackened in a few minutes if the efficiency be pushed even to two watts per candle. Moreover, with an efficiency of two watts per candle the life of a carbon filament up to the point of burn out is very short and when operated in nitrogen is very much shorter than when operated in a vacuum.

One important feature of my invention consists in so correlating the filament material with the atmosphere that the atmosphere reduces the tendency of the material to vaporize, and makes it possible to operate commercially at higher efficiencies than can be realized with the same material in a vacuum.

Nitrogen does not attack the tungsten filament, even at the high temperatures mentioned, though it may react on tungsten vapor in the lamp, with the formation of nitrid of tungsten, a material which is less opaque than tungsten. In addition nitrogen is peculiarly suitable as an atmosphere because of the fact that it has a low heat conductivity.

The losses from the filament are of three sorts: first, the direct radiation; second, the conduction through the atmosphere in the bulb; and third, convection. Direct radiation of energy from the filament is desirable, since it is this radiation, or a portion of it, which constitutes the light. The other two losses are harmful and should be minimized as far as possible; in commercial practice they have been reduced to the lowest limit by the use of a very high vacuum.

In place of nitrogen I may use various other gases or vapors, provided that they are properly correlated to the material of the filaments. For example, I may use with a tungsten filament, which filament I have heretofore found to be the best suited to my invention, an atmosphere consisting of argon, or mercury vapor, or other gaseous filling having sufficiently poor heat conductivity and satisfying the other requirements herein indicated. Carbon monoxid may also be used as an atmosphere in the lamp but is not as advantageous as those already mentioned. Hydrogen, however, is distinctly unsuitable because it has good heat conductivity and because it appears to dissociate at the high temperatures at which the filament of my improved lamp must be run, the temperatures being in excess of that of a tungsten filament when operating in a vacuum at an efficiency of one watt per candle. The pressure of the atmosphere in the bulb should be relatively high. I obtain good results for example with a pressure (measured when the lamp is cold) of 300 millimeters of mercury, or as low as 50 millimeters, but higher pressures are preferable, and indeed I usually employ pressures of about one atmosphere. The pressure should not however be so high as to involve any danger of destroying the bulb when the filament is heated. Not only do these high pressures, when utilized in accordance with my invention, reduce the tendency of the filament to vaporize or waste away, but the convection currents set up in the gas surrounding the filament serve to convey away from the vicinity of the filament any vapor which may be emitted. By properly proportioning and designing the parts the material constituting this vapor may be deposited at portions of the lamp where it is not objectionable. For example, in the lamp shown in Fig. 1 the

upper portion of the lamp bulb acts as such depositing chamber, while the lower portion remains clear. The depositing action is different than in a vacuum lamp for in the latter case the depositing area in the bulb and the light emitting area largely correspond.

With the ordinary incandescent lamp a very minute emission from the filament will blacken the bulb and seriously reduce the total efficiency, but in lamps constructed in accordance with this feature of my invention the life of the lamp is not so limited, and a very considerable loss of material from the filament can take place. From this point of view it is desirable to operate with filaments of large diameter. But there are other reasons why the diameter of the filament has an important bearing on my invention. I have already spoken of the loss of energy by convection and conduction; I have found that within moderate limits these losses are approximately independent of the size of the filament; that is to say as between a filament 10 mils in diameter and a filament 3 mils in diameter there is very little difference in the magnitude of the conduction and convection losses, but the surface areas of the two filaments are in the ratio of ten to three, and as the light emission at a given temperature is proportional to the surface, the 10-mil filament will radiate more than three times as much light as the three-mil filament, and it is this fact, in combination with the reduced vaporization obtained by suitable choice of filament and atmosphere, and the other features of invention herein described, which enables me to attain the efficiency above indicated.

In a lamp made in accordance with my invention, with a 10-mil filament operating at an efficiency of .52 watts per candle, I find that the filament is operating at a temperature which, if the filament were in vacuum, would correspond to an efficiency of 0.37 watts per candle; the difference of 0.15 watts represents the convection and conduction losses. Of course if an attempt be made to operate an ordinary tungsten filament incandescent lamp at any such efficiency as 0.37 or even 0.52 it rapidly blackens and is destroyed. By employing filaments of still larger diameter, and especially if they be concentrated by coiling or otherwise, the efficiency may be still further raised. Thus I have caused lamps to be constructed in accordance with my invention having coiled or helically-wound filaments of tungsten wire of 20 mils in diameter and operating with a current in the neighborhood of 20 amperes. The candle power was comparable to that of an arc lamp and the efficiency was about .4 of a watt per candle. Owing to the large size of this lighting unit the bulb was made very large to avoid overheating.

An incidental but valuable result of my invention is the elimination of the so-called "Edison effect," which renders the lamps of my invention peculiarly suited for high-voltage work, though the large filaments which I find give the best results also render the lamps suitable for series circuits carrying currents of considerable magnitude, on which the voltage consumed in each lamp is usually relatively low.

The advantages of a large filament may to a considerable extent be realized by the use of a small filament in concentrated form as a coil or spiral form, as shown in Fig. 2. Moreover, as already indicated, the winding of a large diameter filament in concentrated form, as by coiling, still further increases the efficiency attainable.

Fig. 3 shows a lamp in which the spiral filament 12 is located practically at the center of the bulb 13 and is supported by heavy bare tungsten leads 14. The lamp of Fig. 3 differs from the lamp of Fig. 2 in that the bulb is spherical instead of elongated. In this case the bulb must be of considerable size, and in fact in all cases it is better that the bulb should be of relatively large size with respect to the filament in order to avoid overheating.

The heavy tungsten leads 14 are capable of enduring the intense heat of the gases without giving off water-vapor, and these gases as they rise become cooler so that when they reach the seal 15 and the adjacent glass parts, they are prepared to deposit the tungsten which they carry with them and at the same time do not cause harmful heating. I find however that the use of long tungsten leads, though highly desirable, is not essential. For example, in Fig. 4 and Fig. 5 I have shown an arrangement by which the filament may be so supported that the hot gases which arise from it do not come in contact with the seal or with the supports. This result is secured in Fig. 4 by locating the filament 16 above the seal or glass support 17, in which case the filament may be carried by short leads 18, which may be of tungsten, molybdenum, or other suitable material, which may extend up from the seal 17. Similarly in Fig. 5, the seal 19 extends in from the side of the bulb horizontally.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. In an incandescent lamp, the combination of the closed lamp bulb, a gaseous filling therein of substantial pressure at the operating temperature of the lamp, and of substantially poorer heat conductivity than hydrogen, and a filament of such high melting point and low vapor pressure that it may be operated during a long useful life at a temperature higher than that of a tungsten filament operating in a vacuum at an efficiency of one watt per candle.

2. In an incandescent lamp, the combination of the lamp bulb, a gaseous filling therein of considerable pressure at the operating temperature of the lamp and of poor heat conductivity, and a filament of metal having such high melting point and low vapor pressure that the filament may be operated during a commercially useful life at a temperature higher than the temperature of the filament of a vacuum tungsten lamp operating at an efficiency of one watt per candle.

3. In an incandescent lamp, the combination of the lamp bulb, a gaseous filling therein of substantial pressure at the operating temperature of the lamp and having a heat conductivity poorer than that of hydrogen, and a filament of large effective diameter and of metal having high melting point and low vapor pressure so that the filament may be operated during a long useful life at a temperature and at an efficiency higher than would be permissible to give the same useful life if the filament were operated in a vacuum.

4. The combination of a lamp bulb, a filling therein of dry nitrogen at a pressure materially in excess of that corresponding to 50 millimeters of mercury and a filament of tungsten of large effective diameter, the filament being thereby adapted for operation at a temperature higher than that which it would have if operated in a vacuum at an efficiency of one watt per candle.

5. An incandescent electric lamp having a filament of tungsten of large effective diameter and a bulb or globe therefor filled with dry nitrogen at a pressure as high or higher than that corresponding to 300 millimeters of mercury, the filament being thereby adapted for operation at a temperature higher than that which it would have if operated in a vacuum at an efficiency of one watt per candle.

6. An incandescent electric lamp having a filament of large effective diameter formed of refractory metal having very low vapor pressure, and a bulb therefor filled with a gas of poorer heat conductivity than hydrogen and at a pressure exceeding that corresponding to 50 millimeters of mercury, the filament being thereby adapted for operation at a temperature higher than that which it would have if operated in a vacuum at an efficiency of one watt per candle.

7. An incandescent lamp consisting of a lamp bulb, a filament of a material having a high melting point and low vapor pressure located therein, the upper portion of the lamp bulb serving as a condensing chamber or deposit chamber for material vaporized from the filament, a gas or vapor of poorer heat conductivity than hydrogen and of a pressure materially in excess of that corresponding to 50 millimeters of mercury, and a filament so proportioned in size that the lamp will emit light at an efficiency higher than the efficiency the filament would have in a vacuum if operated so as to have approximately the same useful life.

8. An incandescent lamp having a lamp bulb provided with a space serving as a deposit chamber, a filament of a material having a high melting point and low vapor pressure located below the deposit chamber, and an atmosphere in the bulb consisting of a pressure of gas or vapor materially in excess of 50 millimeters of mercury and having poorer heat conductivity than hydrogen.

9. An incandescent lamp having a lamp bulb provided with a space serving as a deposit chamber, a filament located below the deposit chamber, and an atmosphere in the bulb consisting of a pressure of a poor heat conducting gas materially in excess of 50 millimeters of mercury, the said filament being of such diameter and of such material that it may be operated at a temperature in excess of that of a tungsten filament operating in a vacuum at an efficiency of one watt per candle for a long time before wasting away to such a point as to break or become of unduly high resistance.

10. The combination in an incandescent lamp having during operation an atmosphere in the bulb of relatively high pressure and of poorer heat conductivity than hydrogen, of a filament of a material having a high melting point and low vapor pressure and capable of operation without undue blackening of the bulb for a reasonable commercial life at an efficiency higher than could be obtained with the same length of life with such a filament in a vacuum.

11. The combination of a closed bulb or container, a gaseous filling therein of a pressure when the device is in operation materially in excess of that corresponding to 50 millimeters of mercury and of substantially poorer heat conductivity than hydrogen, and a filament of large effective diameter, and of material of such high melting point and low vapor pressure that it may be operated during a long useful life at an efficiency better than one watt per candle.

12. In an incandescent lamp, the combination of the lamp bulb, a tungsten filament therein, and a gaseous filling, the effective diameter of the filament being sufficiently large and the heat conductivity of the filling being sufficiently poor to permit the lamp to be operated with a filament temperature in excess of that of a vacuum tungsten lamp operating at an efficiency of one watt per candle and with a length of life not less than that of such a lamp.

13. An incandescent electric lamp having a closely coiled tungsten filament, the coil

giving the effect of a filament of large diameter, an inclosing bulb and a filling of gas having a materially poorer heat conductivity than hydrogen and at a pressure as high or higher than 300 millimeters of mercury, the filament being adapted for operation in said gaseous filling at a temperature higher than that which it would have if operated in a vacuum at an efficiency of one watt per candle.

In witness whereof, I have hereunto set my hand this eighteenth day of April, 1913.

IRVING LANGMUIR.

Witnesses:
W. J. Gregan,
Leo C. Foss.

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DEFENDANT S' EXHIBIT L

CKET
#72

THE DEVELOPMENT OF COILED X-WIRE COMMERCIALLY IN THE RESEARCH LABORATORY.

Before relating the development of coiled X-wire, a brief description of B and C wire will be given. This will aid in obtaining a clearer conception of X-wire, when this wire is described.

B & C-Wire.

In lamp manufacture at the present time two kinds of tungsten wires are generally used. These are known as B and C wire, or as thoriated and non-thoriated wire respectively. In appearance and in certain properties they are practically alike; such as electrical resistance, melting point, and emissivity or light giving qualities. There is however a decided difference in the physical structure B and C wire and it is this difference which gives them respective properties-each suitable for a particular type lamp. How this difference in structure is brought about in the two wires will now be briefly given.

MAKING B & C-wire.

In making both B and C wire, the tungsten metal powder, obtained by reducing the tungsten ore is pressed and sintered into a slug. The B slug differs from the C slug at this point in that B contains a small amount of thoria while the C contains no thoria and the tungsten powder, from which it was made was previously given a special treatment. Both slugs are weak and

Page Tightly Bound

brittle and generally composed of small individual crystals equiaxed in shape - that is, crystals having practically the same diameter in all directions. Now as both are drawn down into wire, these crystals are pulled out of their original shape and become fibrous. This structure is shown in following photograph.

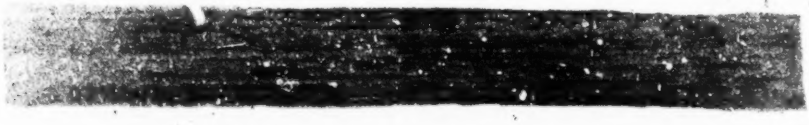


Fig. 1—Drawn Tungsten Wire. Magnified 300 Diameters

Fig. 1a

which is a microscopic photograph of regular 75 watt type C-wire magnified 300 times. The well-known black B and C wire before oxyannealing is in this fibrous condition - which incidently is the most ductile and strongest state in which tungsten wire can be made.

When both these fibrous wires are now oxyannealed (that is, passing wire thru heated zone in forming gas at about 1800°C) to remove the aquadag and the strain produced while drawing) the crystal structure again begins to form but not to the extent where the crystals are equiaxed and brittle as in the original slugs.

When the B and C wire are then mounted in lamps and first lit up the structure in a few minutes usually assumes nearly its final crystal structure and a general idea of these are shown in following photographs Fig 3 and Fig. 4.

Fig. 3

Fig. 4

In the B-wire (Fig.3) the presence of thoria prevents the crystals from gowing any considerable length while in the C-wire (Fig.4) there are comparatively few crystals, rather long and more or less overlapped.

It is this difference in the crystal structure which gives these two wires their different properties. The B-wire in a lamp with its smaller crystals, shows a larger amount of sag (coiled)/but possesses considerable strength and is therefore used in vacuum lamps where straight filaments are used and the sag tendency therefore small. The C-wire on the other hand, with its longer and overlapped crystals offers considerable resistance to sag and is therefore very suitable for coiled filament lamps where sagging would be detrimental to the lamp. The strength of C wire in lamps (after burning) is less than the B although the B wire before burning is more brittle and tends to break while

coiling.

These are then the principal differences between B and C wire. Altho C wire is essentially a non-sag wire, yet because of the conditions to which it is subjected in a lamp, t is always more or less initial sag when the lamp is first lit up, and occasionally a time sag, both depending on the extent to which the filament is supported in the lamp. There is, however, a non-sag wire which when mounted in a lamp will sho no sag whatsoever, when burning, either initially or with tim It is known as X or overlapped wire.

X-WIRE.

This wire may be described as C-wire which has been given a special temperature treatment before it is mounted in lamp, either before or after oxyannealing. This treatment changes the fibrous wire over into the longest crystals possi thruout the whole length of the filament. (There is also a te dency for long crystals to grow when C-wireis first lit up in lamp, but this tendency is counteracted by cooling effects of leads and supports and a tendency to sag at the start). Th difference between C and X wire may be represented by followi sketch:

X-WIRE C-WIRE

Fig. 5

re long crystals are only found between supports and leads, the lower temperature at leads and supports allowing only small crystals to form at these points.

Making X-wire up until recently has been confined to straight wire. This was produced by passing straight wire thru short heated zone on a machine built for that purpose in Research Laboratory. This straight wire, altho quite ductile along most of its length, possesses points where it is quite brittle. Because, however, of its unusual non-sag properties, work was begun in Research Laboratory last Fall to study all the characteristics of the wire and particularly to determine and develop its commercial possibilities. It was realized that if the exceptional non-sag properties could be utilized without losing other necessary properties, important improvement in coil filament lamps would be possible.

The development work of this wire, including the new method found for making coiled X-wire commercially, will now be related briefly.

MAKING STRAIGHT X-WIRE and THEN COILING.

This work was begun by first making straight overlapped wire and then attempting the process of coiling. After considerable time spent and many attempts to coil under various conditions the continual breaking of overlapped wire was reduced so thatunder best conditions obtainable, lengths as long as four feet were coiled before a break occurred. Under the very best conditions, however, and with most delicate adjustments, the best coiled wire obtained was not evenly spaced and the life of the lamps, from the best

Page Tightly Bound

coiled filaments selected, was usually less than one-half the regular C-wire.

COMBINED TREATING AND COILING.

As this method was not at all promising from a commercial standpoint, attempts were made to produce the overlapped structure by heating the filament to the overlapped temperature between an entering pulley and mandrel on laboratory coiling machine, thus combining two operations in one. This method was tried out by placing the coiling machine in a hydrogen atmosphere. The temperature was easily obtained and the coiling comparatively easy, but the resulting coils were extremely brittle.

TREATING COILED WIRE.

As the method just described was also not promising, work was next begun in attempts to overlap the C-wire after it was coiled. Attempts to pass the coiled C-wire thru a coiled tungsten heating element in hydrogen atmosphere failed as the turns pulled out at or before the proper overlapped temperature was reached.

STATIONARY TWO MERCURY ELECTRODE METHOD.

Next the possibility of passing coiled C-wire thru two mercury electrodes was tried out. On the regular overlapped wire machine, the upper electrode of tungsten jaws was replaced by a mercury electrode similar to the bottom one on machine. A pulley and belt arrangement was also provided to guide the long coiled C-wire thru the two mercury electrodes. In this arrangement also, the coiled wire pulled out when the proper treatment

temperature was approached, the wire, however, showing the properties of the overlapped structure. Attempts were then made to reduce the tension to a minimum by dropping the coiled filament down thru the mercury electrodes, but even the minimum amount of tension required to pass the wire thru, pulled out the coils. In one of these latter attempts the current was incidently turned on prematurely before sufficient hydrogen had passed thru the hood.. In the resultant explosion, the motor driving the pulleys and moving the coiled wire, was not started. The coiled wire remaining between the two mercury electrodes was thus given a temperature treatment while wire remained in a stationary position. On examination this wire showed all the properties of non-sag wire. This stationary method was then repeated (without the explosion) and all filaments subsequently made and tested in either vacuum or gas-lamps showed no initial or time sag. (The distance used between electrodes was about 8 mm. the wire being treated in a vertical position. The treatment temperature was between 2800 and 3000°K).

In treating a long coiled filament it is placed on pulleys already referred to and threaded thru the two mercury electrodes. The current is then applied while the filament remains stationary. After about one-half minute treatment the current is turned off and the coil then moved thru the mercury electrodes almost the distance of the treated portion, so that another untreated portion will be between the electrodes for the next treatment. A little overlapping thus insured no small

portion of the filament to remain untreated. The current is then turned on again and the whole process repeated until the whole length has been treated.

This was a considerable step forward toward a commercial method for making overlapped coiled wire, yet, it involved a number of undesirable features, particularly from a commercial standpoint, among which were the following:

1. Inefficient from a production standpoint.

2. A tendency toward uneven spacing while treating because the turns come closer together at bottom due to filament's own weight and also tendency of coil to catch at times in bushings of mercury electrodes.

3. The continual handling of mercury, its vaporisation and the necessity of dissolving off mercury with HNO_3 from the filaments after treatment.

4. Special mechanism required for handling treating and dissolving long coiled filaments.

NEW METHOD FOR MAKING COILED L-WIRE.

In turning to a better stationary treatment method it was found that by heating cut length filaments in some sort of heated container, the above objectionable features were all eliminated. By this method the coiled filaments are not heated directly by passing a current thru them, but indirectly. The essential principle in this method as well as in the stationary two mercury electrode method is supporting the coiled filament being treated sufficiently so that no sag can result during treatment and all points obtain an even temperature treatment before the filaments are mounted in the lamp. A brief description of

this method as first carried out and by which the first non-sag coiled filament wire made will now be given.

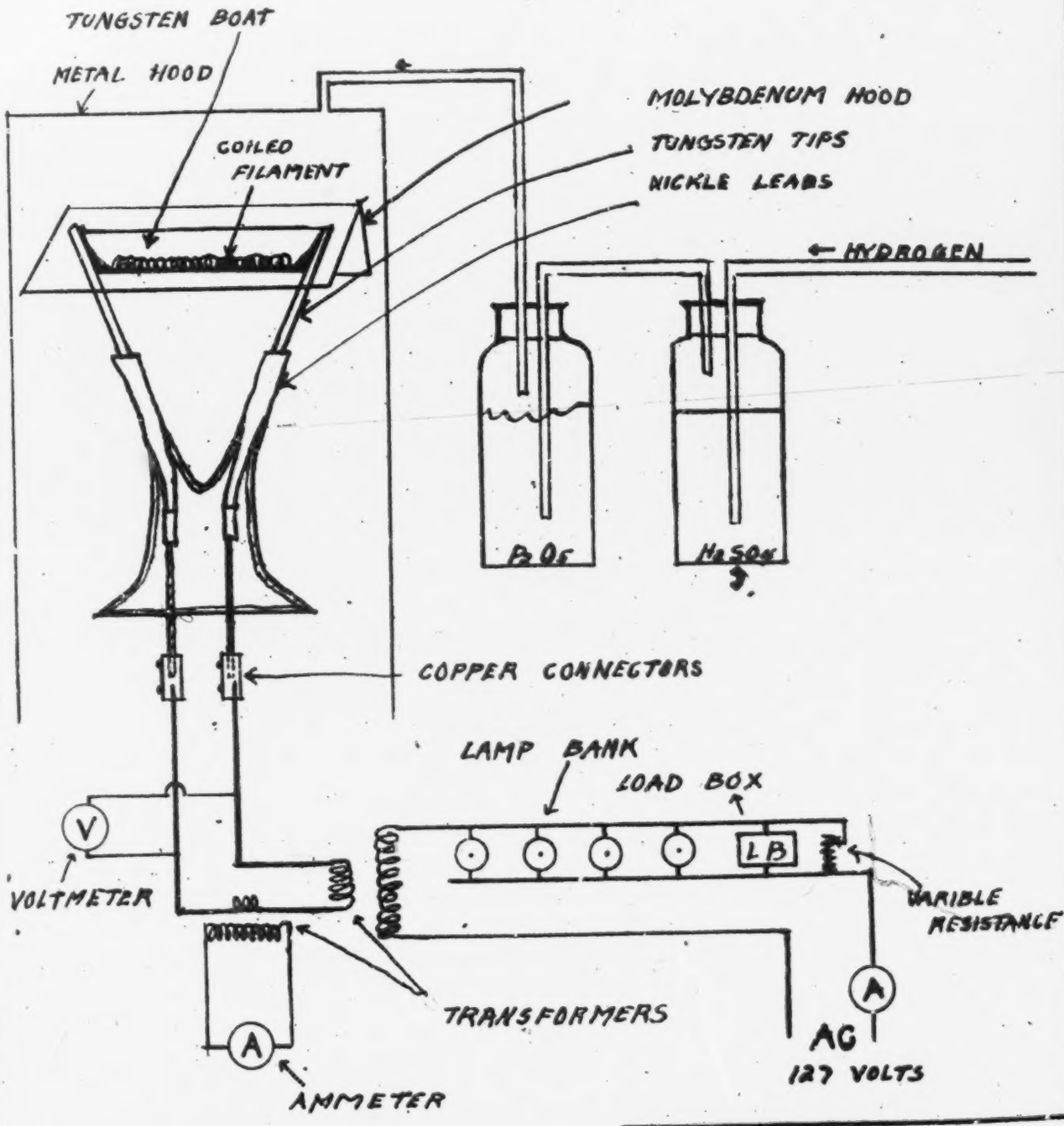
(a) DESCRIPTION of APPARATUS.

A V shape boat was made up from tungsten ribbon (size of ribbon - 50 mm x 10 mm x .0026"). The ends of the V shape trough were closed by pressing the two sides together. The ends of the boat were then placed between double tungsten tips of heavy nickel welds of a high wattage lamp stem. The tungsten boat was then arced to the tungsten tips and the inside of stem was filled with cement to prevent heavy leads breaking the glass seal, which simply held leads in proper stable position. This improvised heater was adjusted in overlapped wire machine replacing the two mercury electrodes and connected in the secondary of a transformer circuit. A metal hood, thru which the hydrogen gas passes, came down over apparatus, during treatment. The current thru the boat is controlled by lamp banks, load boxes and rheostats in the primary circuit. The following sketch will indicate the essentials of whole apparatus and also electrical connections.

(see next page)

(b) TREATMENT

Regular cut coiled C filaments were placed in the boat described (up to about 40 at one time, depending on the size of coils used for treatment). In the first tests a few larger coils were placed on top of those to be treated, to act merely



SKETCH OF APPARATOS USED IN MAKING FIRST NON SAG COILED FILAMENTS BY NEW METHOD.

EDISON LAMP WORKS
ENGINEERING DEPT.

App. by P.A. KOBER

DATE APRIL 4 1924

HW-3174 3m 8-25-28
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as a covering, owing to considerable convection currents of hydrogen passing over boat; thus insuring more even heating. A metal V shape baffle plate was adjusted above boat and close to it, to not only avoid the hydrogen convection current effect on filaments, but also to reflect the heat back on top coils in boat. This seemed to be quite effective.

The current required for the particular boat (dimensions already given) to obtain temperature of about 3000°K was 150 amperes with about 8 volts across secondary terminals of transformer. The first tests were run at lower temperatures and at a temperature equivalent to about 135 amperes the change toward the overlap structure began. The procedure thus far has been to turn on the current to give approximately about 2500°K and then bring up at once to about 3000°K and hold for about one minute. The current is then turned off and after about one half minute the filaments are ready for mounting.

NO-SAG PROPERTY OF COILED FILAMENTS TREATED BY NEW METHOD

When cut coiled filaments are treated by the method just described, the fibrous structure of the C-wire from which it was made changes to the long overlap crystals, which show unusual resistance to sag. These filaments, for example, when coiled on 30 mil mandrel and mounted in lamps <u>without any supports</u> and the normal cut length used for standard lamps, show absolutely no initial or time sag while similar filaments not treated sag immediately, so that they touch bulb.

In Fig. 6 are shown lamps with B, C and X coiled filaments treated and not treated. The relative sag of each is strikingly shown.

Fig. 6.

P. A. KOBER.

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Chas McClain
June 12/1924

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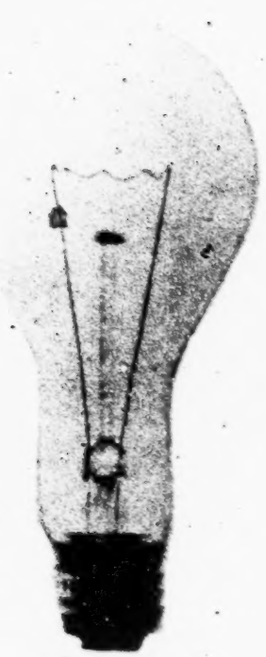
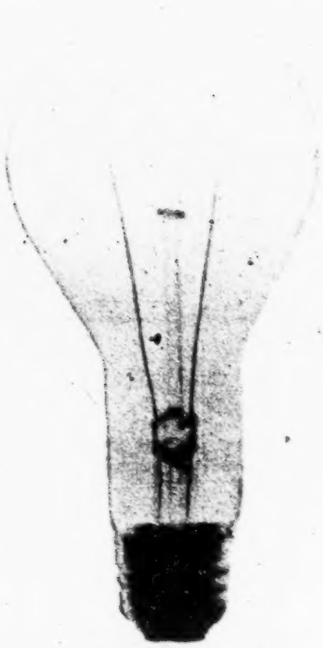
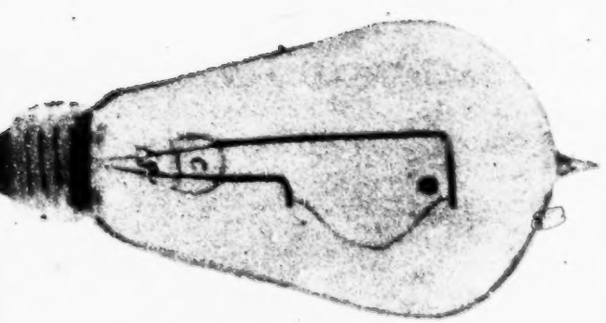


B WIRE

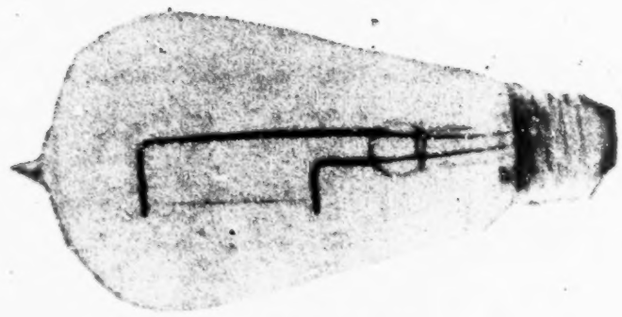
C WIRE



CX WIRE



C WIRE
20 MIL MANDREL



CX WIRE
20 MIL MANDREL

DEFENDANT S' EXHIBIT M

391

P A Kober - Harrison Copy

RESEARCH DIVISION - EDISON LAMP WORKS

Weekly Report

of

P. A. Kober

April 14th., to May 5th., 1924.

5035-1 Properties of Overlapped Tungsten Wire.

COILED OVERLAPPED WIRE

(a) Ductility Tests.

The following tungsten wires have been coiled and treated by new heat method. Their response is indicated relatively by following approximate ductility values:

(These values are obtained by pressing down on tungsten coils with a 53 mil nickel rod, 100 times and deducting one per cent for each break).

Wattage	Mandrel Size	Lot #	% Ductility (coiled-Kober)	% Ductility (straight-Engli
75	20	NCA - 35	52	88
75	20	CB-35-LB	73	93
75	20	CW-42-A	0	19
75	20	C-54-C	24	80
75	20	C-49-C	78	94
75	20	DB - 346	84	94
75	11	CC-1	70	
75	11	C-47-C	15	94
75	11	C-52-B	40	
75	11	C-43-8	72	95
75	11	C-2-54	80	95
75	11	C-47-67-R		
75	11	C-45-5	76	
75	11	C-44-2	63	
75	11	C-49-67	68	
75	11	C-54-B	90	95
75	11	C-B-364-C	87	96
75	11	CM-2C	73	95
75	11	CB-351	93	99
75	11	C-55-1-13	56	99

Wattage	Mandrel Size	Lot #	% Ductility (coiled-Kober)	% Ductility (straight-English)
		Special Wires		
25	11	I-61-A-3		96
25	11	B-6-21		
40	10.5	C-48-16	70	
25	10	C-51	86	-
25	10	C-48-16	0	-
25	5	C-A-46-CC(.3% carbon)	64	-
25	5	CC-1	80	-
25	5	SS-2(.05% thoria)	0	-
25	5	SS-1(.2% ")	0	-

In a few lots of wires above, the ductility is relatively low for the coiled wire, while the same wire, before being coiled, gave a good ductility by Mr. English's straight wire ductility test. There are three possible factors which may cause this:

(a) annealing on mandrel immediately after coiling before cutting.

(b) firing.

(c) conditions incident in coiling.

These factors will be investigated fully. The following data has already been obtained in this direction:

(a) Difference between fired and unfired filaments.

Lot #	% Ductility Fired	Not Fired	Wattage
CB-348-C	96	88	25
C-51	85	86	25
C-43-8	72	55	75

(b) On 25 watt treated filaments, the fired showed

MI2

a lower strength test than the unfired. Test run by Mr. Beck.

These results indicate that firing may effect th overlap response, favorably, unfavorably, or not in any direct

(b) Data Regarding Difference Between Pacz Non-sag Wire and Non-sag Coiled Wire by New Method.

The following tests were run to determine the rel tive sag of regular C wire (Pacz) after burning in lamps and n method where filaments are treated before they go into lamps.

1. Producing non-sag wire in lamp by burning C-filament vertically without any supports.

Regular 75 watt wire was coiled on 20 mil mandrel, 329 T.P.I., mounted straight, on two leads without any support and burned in a vertical position. The filament was brought in 10 volt steps to 3000°K and held at that temperature for 4 minutes. The filament buckled at the bottom end during burn A straight portion of this filament was cut out after burning remounted in another lamp without any supports. Three filam treated in this manner showed no sag when lit up at about 290 while one showed only a small amount of sag. Similar filame treated by new method, of course show no sag whatever.

TO DETERMINE IF NON SAG C4N 13E PRODUCED IN LAMP INSTEAD OF NEW WAY

2. Tests to show amount of Sag when regular standar 75 watt 115 volt regular C filaments are mounted without any supports and with one support.

Regular 75 watt 115 volt standard C coiled fil when mounted between two leads without any supports showed

iderable wag when flashed, while same wire previously treated
y new method showed no sag whatsoever. This was also true
or filaments mounted with one support. The sag, of course,
eing somewhat less for the untreated C-wire. (These lamps are
eing held as an exhibit).

3. Determining amount of sag of regular C-filaments when mounted with regular number of supports and burned.

Regular 75 watt 115 volt standard C-coiled filaments ere mounted with full number of supports and flashed. A second ot was flashed and then burned for 24 hours at normal volts and third lot was flashed and then burned at 2900°K for 45 minutes. hese filaments were all removed from the lamps and remounted be- ween two leads without any supports and sag tested at 115 volts.

Treatment	Sag
Flashed	none
Flashed and burned at normal volts for 24 hours.	none
Flashed and burned for 45 min. at 2900°K	none

hese results indicate that the crystal growth produced in lamp as sufficient to prevent sag when remounted without any supports.

4. CC-1 Wire (Hercules).

Special coiled filaments (Hercules wire - CC-1 - 5 watt-115 volt) submitted by Mr. English, were mounted on stems ith no supports, with one support, and with regular number of upports(3), both untreated and treated by new mthod. The follow- ng sag results were obtained when lit up at normal volts;

Supports	Treated	Not Treated
None	no sag	considerable sag
One	no sag	less sag
Three	no sag	same sag as regular C-wire.

These results show that CC-1 wire when not supported sufficiently when first lit up shows same sag tendency as average run of regular C-wire.

2. Variation of gas during treatment.

The following data obtained while treating filaments from one lot number shows that the gas is an important factor in response to overlapped structure. The following successive tests were run with practically same method of treatment but the gas line pressure varying continually from zero to 11" of water. Our check lot number was used (C-43-8) giving usually a ductility between 70 and 72%.

Test	% Ductility
(a)	0
(b)	0
(c)	64
(d)	20
(e)	72
(f)	84

6. Relation between electron emission and response to overlapped treatment.

Two spools of wire were submitted to Dr. Koller, having a ductility of 18.8 and 93.6% respectively. Under the condition of treatment these ductilities represent relatively the response to the overlapped treatment:- Results follow:

Lot #	% Ductility	Emission
CB-346-A	93.6	low
CW-42-A	18.8	high

Dr. Koller reports that CW-42-A has some im-
ity which gives the higher electron emission and that it is
ily eliminated by heating.

7. Elongation tests of filaments treated and not treated taken from life tests that have come down.

This test is indicative of the ductility of the
led wire. (The filament is removed from lamp and every 5
portions are pulled out until a break occurs. If a portion
ls out at 5 mm the elongation is considered 100%).

Dr. Gordon obtained the following values from first
ee 75 watt life tests and the 40 watt life test given on
ached sheet.

	Wattage	Regular Lamps not treated	Treated by new method
1.	75	60%	690 %
2.	75	420	437
3.	75	20	1030
	40	0	360

(8) The difference in sag between C and CX wire after aging in lamps, may be shown by photometric readings obtained on first 40 watt 115 volt life test lamps.

Treated		Not treated	
Watts	L.P.W.	Watts	L.P.W.
39.3	10.39	39.5	9.37

The treated lamps showed an increase of about 10%
of sagging & caused a decrease
M16

which can be directly attributed to the initial sag of untreated filaments.

(c) On attached sheet is given life and strength tests completed to date.

These results show the following:

(a) Life.

The treated wire averaged 80% normal BO of regular and also 80% of regular at 11.8 L.P.W. In other words, there is no appreciable difference in lumen maintenance between treated and wire not treated after aging. This means that after initial sag the non-treated wire does not sag further.

(b) The treated 40 watt lamp gave 116% the BO life of the untreated.

(c) Strength.

The first two 75 watt tests show greater strength for the treated than for the untreated - both on bump tester and under vibration. The third and fourth tests show the reverse on the bump tester but equal strength on vibrator.

The strength on test 171 shows good strength for the untreated and poor strength for the treated. It may be noted here that all failures on treated filaments were broken filaments close to the leads, no doubt due to welding.

PAK:FC

P. A. KOBER.

[fols. 398-399] DEFENDANTS' EXHIBIT R

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File #20

March 2, 1922. Dict. 1st.

Mr. H. M. Fernberger. Mr. H. N. Frear.

Below is given some of the regular microphotography followed by the B. T. H. Company, which may be of interest to you.

Micro-Photography

Mr. Smeaton is in charge of taking microphotographs of ingots, filament and anchor wire.

The mounting of specimens is done in Rose's metal in a copper capsule ½ in. x ½ in., and the Rose's metal comes well above the top edge of the capsule. The specimen is first rubbed down with a piece of emery cloth held on glass and the emery used is of four different grades, numbers 0, 00, 000 and 0000. Then a wet polishing is carried out on a revolving rubber disk about 4 in. in diameter. This disk is horizontal and consists of a smooth sheet of rubber pasted on the wheel. The abrasive is Abradum, manufactured by the Country Chemical Works, Birmingham, England, and is the 200 mesh size. The wheel is kept moist with distilled water, and it takes about one hour to polish an ingot. The specimen is then etched with potassium ferrocyanide of a 2 to 3% solution for about 30 seconds. It is again wet polished and re-etched. This is repeated three or four times, or as many times as is necessary to produce a good speci- [fol. 400] men surface. The specimen is then dried with a jet of air and no cloth is used. The micro-photographs are made with the aid of a 500 candlepower pointolite lamp filtered through a monochromatic screen. All the metal used in wire manufacture is examined, and a specimen is taken from the slug about one inch from the end.

The limits allowed for grain count per sq. mm. are 1000 to 2000 grains. Below the limits of 1000 grains per square mm., the wire would be too hard. A coarse grained ingot makes the best non-sag wire.

250 feet of wire is drawn from a test ingot to produce about 100 watt "C" lamps, and these lamps are then put on the racks at forced voltage to determine if the wire is non-sag or not. If the wire sags this batch of metal is then used in "B" lamps, otherwise it is used in "C" lamps. A permissible sag is about ⅛". The microscope they use magnifies to about 70 diameters. The Battersea wire has from ½% to 1% impurities in it and these impurities are probably aluminum silicate. The smallest drawn wire filaments they are now making are 0.08 amperes or 6/10th of a mil.

H. H. Needham.

HHN-EF.
CAB.

DEFENDANT'S EXHIBIT S

Copy to Dr. Liebmann.

July 13, 1915.

NON-SAGING FILAMENT WIRE.

Mr. Cowles:

Kindly prepare a number of small batches of metal, about 500 grams to a lot for the production of non-saging filament wire. These batches to contain small percentages of addition products, such that these products will not interfere with the working quality of the metal and yet impart that non-saging effect to the wire.

I would suggest that we try small percentages of silica, of titanium, of lime, of boron or any other addition product that you might consider beneficial for this purpose.

When you have five lots of these special metals ready, let me have them so that I can have them treated and swaged, and thus be better able to tell the relative working quality of the metals.

Si Ti Ca Ta U B .5-.027 Th .75
1-.03 .4-.024 1.6-.02 .5-.04 .5-.024 C. A. Laise.

CAL/U.

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PAGE

[fols. 402-409] DEFENDANTS' EXHIBIT CCC

UNITED STATES PATENT OFFICE.

JAMES ALEXANDER SCOULAR, OF HAMMERSMITH, LONDON, ENGLAND, ASSIGNOR TO DICK, KERR & COMPANY, LIMITED, OF LONDON, ENGLAND.

MANUFACTURE OF METALLIC FILAMENTS FOR ELECTRIC INCANDESCENT LAMPS.

1,104,557 Specification of Letters Patent. Patented July 21, 1914.

No Drawing. Application filed March 14, 1913. Serial No. 754,346.

To all whom it may concern:

Be it known that I, JAMES ALEXANDER SCOULAR, a subject of the King of England, residing in Hammersmith, London, England, have invented certain new and useful Improvements in the Manufacture of Metallic Filaments for Electric Incandescent Lamps, of which the following is a specification.

This invention relates to improvements in the manufacture of tungsten filaments for incandescent electric lamps and has particular reference to that type of process in which tungsten metal in the form of a fine powder is mixed with a binding agent and brought into filament form by squirting the mass through a die.

Many different types of binding agents have been employed, and most of the difficulties in manufacture and the disadvantages of finished metallic filaments have arisen from the binding agent.

The raw material which we employ is tungsten in the form of a very fine powder, which may be obtained for example by the reduction of the oxid at a high temperature with hydrogen or with zinc. The finely powdered metal which we employ is preferably as pure as possible, and it is especially desirable to avoid the presence therein of any considerable percentage of oxid or hydroxid, since the presence of these or other impurities may prevent the production of good filaments. Satisfactory results have, however, been obtained with tungsten powder having an "oxygen absorption" of 24.8 to 25.3 per cent., and a simple test suffices to show whether any given sample can be successfully used in the process. According to this invention the tungsten powder is mixed with a small proportion of sodium silicate solution in the thick gelatinous or viscous form, the mixing being carried out in such a way as to effect a uniform incorporation of the powder with the binding agent. The resulting mass or paste is squirted through dies in any well-known manner so as to form raw filaments. These filaments are then subjected to heat so as to render them conductive and to cause them to sinter into finished metallic filaments. During this process the silicate is substantially eliminated. For example, the squirted filaments may be dried, then baked by the application of external heat, and finally sintered by passing a current through them in an inert atmosphere so as to raise them to an intense white heat.

Instead of baking and sintering the filaments separately, the raw squirted filaments may be subjected to heat in a suitable inert atmosphere so as both to render them conductive and to sinter them in one operation. The best proportion of sodium silicate solution to employ varies to some extent with the physical and chemical qualities of the tungsten powder, the thickness of filament required, and other circumstances; but it should in any case be small, and an excess should be avoided. In most cases I have found the best results to be obtained on using the proportion stated in the following example which is one method of producing tungsten filaments according to this invention with separate baking and sintering operations:—

One hundred and twenty (120) grams of tungsten powder of the kind hereinbefore described, 24 grams of sodium silicate solution of 140° Twaddell (containing about 36.35% of silica, 18.85% of soda, and 44.8% of water), and 4 grams of distilled water, are first mixed by hand in a porcelain mortar, the metallic powder being added little by little, and the mixture may also be rubbed around in the hand, the object being to effect uniform mixing. The mixed mass is then calendered in small quantities (say 30 grams) at a time and during the calendering operation a few drops of water are added if necessary. Thereafter the mass is squirted through a die, the filament on issuing from the press being passed through a hot atmosphere, and collected on cards or trays. The filaments are next dried and then introduced in suitable receptacles (say trays of iron) into a baking furnace. The baking furnace may conveniently be a silica tube furnace and is gradually heated during the baking operation by electricity or otherwise to a temperature of about 900° C., which temperature is maintained for about 20 minutes. During this stage the baking furnace is filled with inert gas, preferably an atmosphere of dry hydrogen at a few millimeters absolute pressure. The filaments after baking are conductive. They are then subjected to a sintering operation, that is to say, an electric current is passed through them in order to raise them to an intense

white heat in an inert atmosphere, preferably an atmosphere of pure dry hydrogen at a reduced pressure. Thus each filament may be sintered first for about three seconds in an atmosphere of hydrogen at about 610 mm. pressure and again for about one second in an atmosphere of hydrogen at about 110 mm. pressure. Some filaments may require a longer treatment with electric current. After sintering the filaments are ready for mounting in lamps.

In the case in which the filaments are rendered conductive and sintered in one operation, the process may be the same as above described up to the drying stage. The dried filaments are then introduced into an electric resistance furnace which conveniently consists of a vertical carbon tube through which a very heavy electric current is passed. This tube is filled with an atmosphere of hydrogen for example by leading hydrogen downward through it. The filaments are suspended in the vertical tube and are raised to the temperature necessary to sinter them.

It is to be understood that the method of forming and finishing the filaments may be varied without departing from this invention. For example the filament as it is squirted may be passed directly into an apparatus in which it is subjected to the subsequent operations. Further, the filaments may be cut into hairpin form or other suitable form at any stage of the manufacture or they may be kept in continuous form.

What I claim as my invention and desire to secure by Letters Patent is:—

1. The herein described process for the manufacture of tungsten filaments for incandescent electric lamps which consists in intimately mixing tungsten powder with a small proportion of sodium silicate solution in the viscous form so as to produce a paste, squirting the said paste to form raw filaments and subjecting the raw filaments to heat so as to render them conductive and to cause them to sinter into finished metallic tungsten filaments.

2. The herein described process for the manufacture of tungsten filaments for incandescent electric lamps which consists in intimately mixing tungsten powder with a small proportion of sodium silicate solution in the viscous form so as to produce a paste, calendering the mixture, squirting the said paste to form raw filaments, and subjecting the raw filaments to heat so as to render them conductive and to cause them to sinter into finished metallic tungsten filaments.

3. The herein described process for the manufacture of tungsten filaments for incandescent electric lamps which consists in intimately mixing tungsten powder with a small proportion of sodium silicate solution in the viscous form so as to produce a paste, calendering the mixture, squirting the said paste to form raw filaments, drying the raw filaments and rendering the same conductive by baking, and thereafter subjecting the baked filaments to a high temperature in an inert atmosphere so as to sinter them into finished metallic tungsten filaments.

4. The herein described process for the manufacture of tungsten filaments for incandescent electric lamps, which consists in intimately mixing tungsten powder with a small proportion of sodium silicate solution in the viscous form so as to produce a paste, calendering the mixture, squirting the said paste to form raw filaments, drying the raw filaments, and subjecting them to heat in a suitable inert atmosphere in an electric furnace so as both to render the filaments conductive and to sinter them in one operation.

5. The herein described step in the process for the manufacture of tungsten filaments for incandescent electric lamps by the squirting process which consists in producing a squirtable paste by intimately mixing tungsten powder with a small proportion of a viscous solution of sodium silicate.

6. The herein described composition of matter for use in the manufacture of tungsten filaments by the squirting process which consists of a paste composed of tungsten powder, and a small proportion of a viscous solution of sodium silicate.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JAMES ALEXANDER SCOULAR.

Witnesses:
E. J. WATT,
JOHN EDWARD BLACKWELL.

UNITED STATES PATENT OFFICE.

ERNST AUGUST KRÜGER, OF SEEHAUSEN, ALTMARK, GERMANY.

PROCESS OF PRODUCING TUNGSTEN FILAMENTS.

1,154,701. Specification of Letters Patent. Patented Sept. 28, 1915.

No Drawing. Application filed August 25, 1913. Serial No. 786,488.

To all whom it may concern:

Be it known that I, ERNST AUGUST KRÜGER, a citizen of the German Empire, residing at Seehausen, Altmark, in Germany, have invented certain new and useful Improvements in the Process of Producing Tungsten Filaments, of which the following is a specification.

The object of this invention is to provide an improved process of producing wire and filaments of tungsten and tungsten alloy. In my invention I use, as raw material for the filament, a mixture of powdered tungsten with a small proportion of carbon and boracic acid or other compound of boron.

My invention consists in a particular manner of carrying out the process of manufacture with the raw material indicated.

According to the invention I first produce a rod consisting of powdered tungsten with a small proportion of carbon and a boron compound, preferably boracic acid, less than 1% of the latter being usually sufficient and only a small trace of carbon, about 0.1%. I may use the boracic acid in the form of powder. I moisten the mixture with water. I may also mix the tungsten powder and carbon alone, and form a rod of this mixture, by pressure, and then impregnate the rod *in vacuo* with a concentrated solution of boracic acid. The rod is then heated to about 1000 or 1200° C whereby the boracic acid is caused to slowly swell and expel the air or other gas present from the minute interstices between the tungsten particles. This expulsion of gas is highly important for the purpose of obtaining nonporous wire. The melting boracic acid cements the metal particles to each other, and at the same time the superficial oxid layers dissolved by the boracic acid. Thus purely metallic tungsten particles come into intimate contact with each other, and can by subsequent treatment be sweated or fused together to produce a perfectly homogeneous structure. When the temperature reaches its higher values the boracic acid is probably reduced to boron, or causes carbid of boron to be formed, with the result that an alloy of tungsten and boron or boron carbid is obtained. This is accompanied by considerable shrinkage of the mass. After the rod has been kept for some time at the temperature mentioned, I heat it to a temperature between 1200 and 2000° C. by means of electric current, in a stream of hydrogen, whereby the metal particles are fused together, and a very homogeneous structure, free from cavities or crevices, is obtained. The rod is then formed into wire by suitable mechanical treatment adapted for this purpose. The presence of the boron reduces the liability to attack by oxygen, so that there is no necessity for careful exclusion of atmospheric air in the course of the mechanical treatment. The rod being free from cavities, the wire obtained is free from those crevices which always occur in forming wire of pure tungsten.

The wire or filament obtained can be used in the manufacture of electric glow lamps.

Inasmuch as the filament of tungsten alloy is quite as efficient as pure tungsten filament, for glow lamp purposes, it is in general not necessary to eliminate the boron by special treatment. As a matter of fact, the heating of the filament in the lamp to a large extent eliminates the boron, which does not blacken the bulb, but forms a thin transparent deposit. The expulsion of the boron from the filament in the bulb also improves the vacuum, the residual air being mechanically deposited, and perhaps in part chemically combined.

If it is desired to have a pure tungsten filament, I heat the filament to incandescence for a lengthy period *in vacuo*, say to a temperature of 2000 or 2200° C. and then again hammer or roll and draw the filament, with heat.

The process described has very considerable advantages over the process of producing filament from pure tungsten. Particles of metallic tungsten are always coated with oxid, which renders it very difficult to bake them together, and the result is that minute cavities are left, into which air peretrates and causes further oxidation. Admixture to the tungsten powder, such as silver and nickel, which have been proposed, do not result in the production of perfectly homogeneous wire, and when such admixtures are expelled they leave the rod in a porous or spongy state, and when the rod is drawn out to a filament, the latter is found to have cracks and crevices.

I am aware that it has heretofore been proposed to manufacture filaments for incandescent lamps by mixing metals such as tungsten and molybdenum with oxids of boron and a binding agent containing carbon, the mixture being heated to carbonize

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the binding agent, and then heated to white heat by current, in a stream of hydrogen. In this process only so much of the metal is used as will render the mixture conductive at ordinary temperatures, so that the whole of the tungsten or molybdenum becomes alloyed with boron.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

The process of producing a filament of tungsten or tungsten alloy, which consists in forming, by pressure, a rod consisting of a mixture of powdered tungsten with a small proportion of carbon and boracic acid or other boron compound, heating said rod to a temperature of about 1000 to 1200° C. at which the particles cake together, then heating the rod to incandescence by electric current in a stream of hydrogen, and then reducing the rod to wire by mechanical treatment.

In witness whereof I have signed this specification in the presence of two witnesses.

ERNST AUGUST KRÜGER.

Witnesses:

WOLDEMAR HAUPT,

HENRY HASPER.

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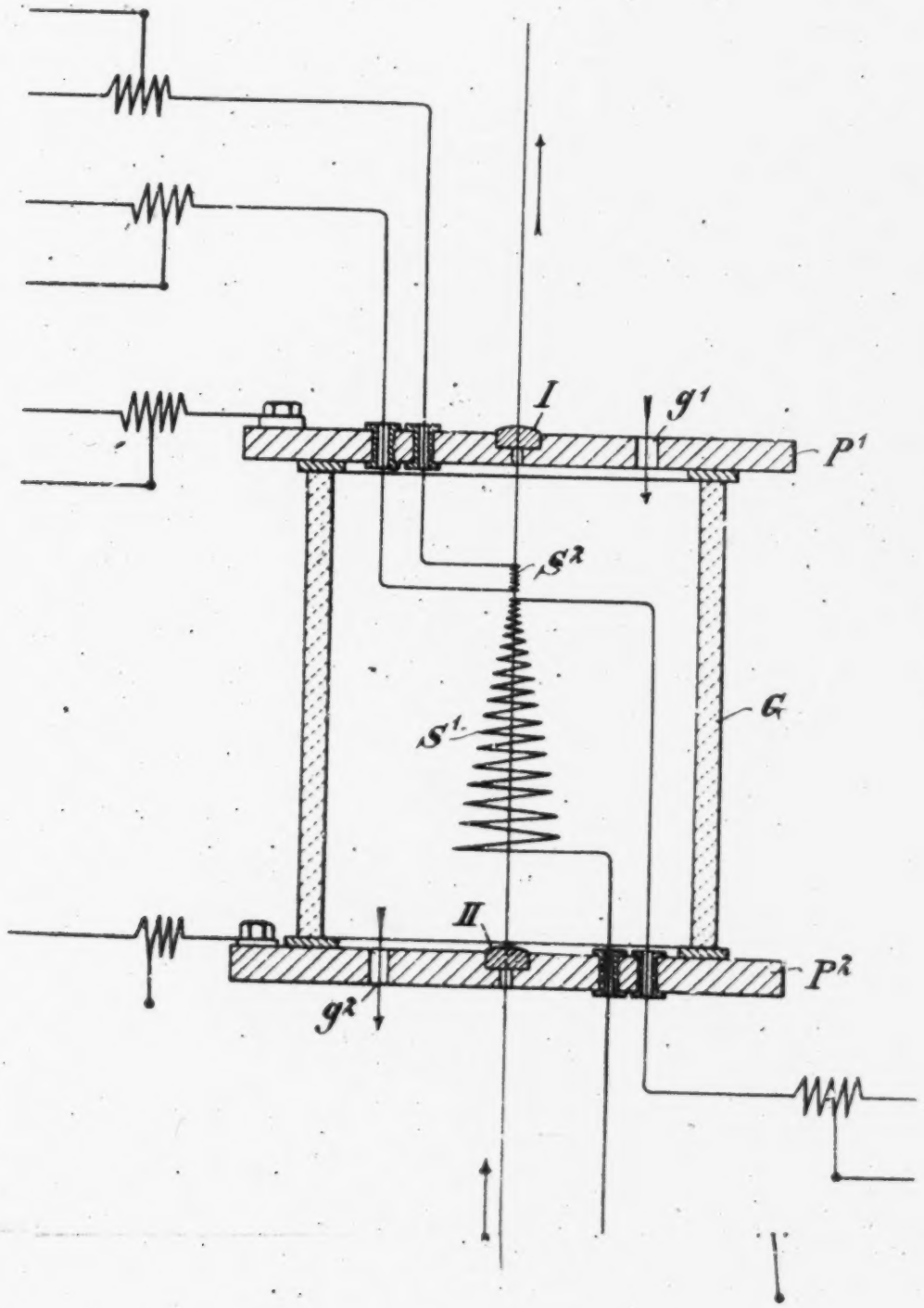
O. SCHALLER.

PROCESS OF PRODUCING METALLIC WIRES, FILAMENTS, AND THE LIKE.

APPLICATION FILED MAY 16, 1914.

1,256,929. Patented Feb. 19, 1918.



Witnesses:

Edwd. F. Tolson,

Bessie A. Rice

Inventor:

Otto Schaller,

by Spear, Middleton, Donnelly & Spear

Attys.

UNITED STATES PATENT OFFICE.

OTTO SCHALLER, OF SÜDENDE, NEAR BERLIN, GERMANY.

PROCESS OF PRODUCING METALLIC WIRES, FILAMENTS, AND THE LIKE.

1,256,929. Specification of Letters Patent. Patented Feb. 19, 1918.

Application filed May 16, 1914. Serial No. 839,121.

To all whom it may concern:

Be it known that I, OTTO SCHALLER, a citizen of the German Empire, and residing at Südende, near Berlin, German Empire, have invented a certain new and useful Improved Process of Producing Metallic Wires, Filaments, and the like, of which the following is a full, clear, and exact description.

According to the known processes for producing bodies or filaments from metals or alloys of metals, the results attained generally possess a crystalline formation. According to these known processes formations may be attained consisting of consecutive large crystals, one joined to the other, and the breaking points between which can be clearly discerned with the naked eye, or other formations are attained consisting of aggregations of very fine crystals.

Since it is not possible to control the ultimate formation of crystals in producing the same, either by the hardening of molten masses or fluxes or by sintering, the crystals in the final metal body are generally in a disordered state.

If now metallic bodies or masses consisting of a plurality of single crystals are subjected to mechanical operations, such as rolling, hammering or drawing, a further disintegrating or deformation takes place, *i. e.* the single crystals are stretched and the whole crystalline mass is compressed, so that the crystals apparently disappear, in that the formation of sinuous or fibrous structures takes place.

In this process the structure is hardened so that the mechanical properties of the metal, when worked, are very considerably influenced, and more particularly its drawing strength, flexibility and hardness.

But the alteration in the form of the crystal is by no means perpetual. Owing to the inherent nature of materials to return to their original crystalline condition and to the peculiar fact that, in course of time the larger crystals grow at the cost of the smaller ones, an alteration takes place in the structure of metallic bodies thus mechanically deformed.

This structural alteration and the reproduction of the original or a coarser crystalline condition results in the loss or partial loss of the mechanically won properties, such as toughness, flexibility and the like.

Structural alterations of this class, which are generally termed recrystallization are due to various circumstances. Thus articles of pressed brass sheet metal will become fragile after a time. Certain classes of iron crystallize, after continuous vibration, while copper wire becomes absolutely brittle under the effect of certain electric currents passed through it.

Recrystallization takes place most often under the effect of heat. Thus for instance a reformation of the previously fibrous structure of pure copper wire takes place between 200° cent. and 300° cent., that of iron at 600° cent. The higher the temperature at which mechanically produced bodies or wires are employed, the more rapid is the recrystallization *i. e.* the return to the brittle condition.

These conditions are particularly noticeable in connection with tungsten and similar brittle and highly refractory metals. Thus, for instance, if bodies of compressed tungsten are converted into wire by mechanical means and such wire or filament is employed in electric incandescent lamps, the recrystallization takes place in a comparatively short period owing to the high temperature, so that the original considerable strength and ductility of the tungsten wire or filament decreases and finally disappears entirely.

These effects are also noticeable in connection with incandescent bodies of tungsten and alloys of the same made according to the sintering process. This class of filament possesses initially an even, finely crystalline structure but, after long use at a high temperature, the smaller crystals combine to form uneven, coarse crystalline structures, so that the wire becomes brittle and breakable in course of time. It has been noticed that incandescent bodies of tungsten recrystallize more quickly when subjected to the action of an alternating current.

The object of the present invention is to avoid the recrystallization of wires or fila-

ments and the like. If, for instance, the wire consists of a single crystal, no alteration of the same will take place.

It has been found by experimenting in this direction, that a crystal of continuous, i. e. practically continuous length, can be produced. This is the subject matter of my application No. 839,122 of even date.

This is particularly the case in connection with substances having a coarse crystalline structure.

The process forming the object of the present invention consists in passing a filament at a certain speed through a short zone of high temperature. In order to produce a long, single crystal, the speed at which the filament is passed through the point of highest temperature, must be equal to, or less than, the speed at which the crystal to be formed can grow, or increase. If these conditions are properly observed, the crystal formed in the hottest zone, and constituting the entire cross section of the wire or filament will continuously grow, the following crystals being incorporated or dissolved, to the same extent as the filament moves. That is to say, that the size of the crystal to be formed is regulated by the speed of movement of the filament through the hottest zone.

The source of heat is immaterial. Electric resistance heating or an electric arc or flame may be employed. The filament may also be heated by passing an electric current through the same and simultaneous exterior heating it to the necessary temperature at the point in question.

This process is applicable to metals, metal alloys and solid solutions of metals, more particularly to that class of substances allied to the larger crystalline structures under certain given circumstances.

As illustrating one method of carrying out the process, it will be described in connection with the accompanying drawing, which illustrates an apparatus suitable for the purpose in a central section on a vertical plane.

Finely divided, or pulverized tungsten metal containing, for instance 2% of thorium oxid evenly mixed with the same is taken as an example. A mixture of these substances is advantageously attained by adding a solution of thorium salt in water to a suspension of tungstic acid in water, and stirring continually the paste thus constituted until it is dry. The mixture, thus attained is then reduced for instance by means of hydrogen, care being taken to retain the substance in its finely reduced state. From this product a plastic mass is made in the usual known manner and a filament is pressed from the same, which is advantageously arranged or collected on suitable plates, in the form of coils, of comparatively great length.

The filament is then dried and glowed, in the absence of oxygen at about 1000° cent. temperature, in order to impart to the same the necessary strength or toughness, for the further preparation.

The filament thus attained is advantageously finally prepared in an apparatus of the kind illustrated in the accompanying drawing.

P^1 and P^2 are metallic plates provided with fine perforations in the center, which are filled with mercury as indicated at I and II. The mercury serves to form a joint and may conduct the current and is kept cool by suitable known means, not illustrated, in order to prevent vaporization of the same during the process. The metallic plates are insulated by suitable means such for instance as a glass cylinder G.

The boring g' serves for the introduction of an inert gas which passes out at g^2.

The metallic plates may be connected to suitable conductors as indicated in the drawing. The mercury contacts may serve to conduct current through the part of the wires I to II, which current heats the filament to any desired temperature, and the intensity of which may be easily regulated by the selection of suitable resistances.

This heating zone may consist of a spiral S^2, which must be capable of being heated to a white heat of the highest grade, in order to provide the highest temperature for the filament at this point.

The filament to be produced is taken through the perforations of the plates P^2, then through the spiral S^1, the second spiral S^2 and finally through the plate P^1.

The spiral S^2 is heated so that the filament receives about 2400° C. at the hottest point. When these conditions have been properly adjusted, the filament is slowly drawn through the plates in the direction from II to I at a speed of approximately 5 meters an hour. This speed must be varied according to the quality of the material used and the temperatures employed, and may be easily found. It must however under no condition be greater than that of the growing crystal.

The filament produced, whether in the above described or in any other manner consists of a single elongated crystal. The greatest advantage of a filament produced according to the present process is that the same does not change its structure under usual circumstances, nor does any recrystallization take place.

Wire or fibrous material made according to the present process can be easily drawn or rolled in a cold state. Care must be taken to draw or roll the same so as to allow the

crystal time to accommodate itself to the conditions.

I claim as my invention:—

The process of producing a metal filament consisting of a single crystal, which consists in passing a metal filament through a zone of a temperature capable of producing crystallization, at such a speed that a crystal is formed and that the crystal is removed from the crystallizing zone while the crystal is being enlarged lengthwise by continued crystallization thereon of the filament following.

In testimony whereof I affix my signature in the presence of two witnesses.

OTTO SCHALLER.

Witnesses:

WOLDEMAR HAUPT,

HENRY HASPER.

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UNITED STATES PATENT OFFICE.

OTTO SCHALLER, OF SÜDENDE, NEAR BERLIN, GERMANY.

FILAMENT OR WIRE FORMED OF A SINGLE CRYSTAL.

1,256,930. Specification of Letters Patent. Patented Feb. 19, 1918.

No Drawing. Application filed May 16, 1914. Serial No. 839,121.

To all whom it may concern:

Be it known that I, OTTO SCHALLER, a citizen of the German Empire, and residing at Südende, near Berlin, German Empire, have invented a certain new and useful Filament or Wire Formed of a Single Crystal, of which the following is a full, clear, and exact description.

If a body or filament is formed of a single crystal, filling out its entire cross section and length, no subsequent alteration of the structure of such body can take place, since the crystal already formed, and which constitutes, as is well known the most stable form of material fills out or constitutes the whole body, so that there is no space for any subsequent increase of the size of the crystal nor for displacement of any kind. In other words a body of this structure is from the beginning in a condition of structural permanency.

Careful observations and experiments have shown that it is possible to produce metallic wires, the whole volume of which consists of a single crystal, even when the length is comparatively great.

We have found that this process is particularly advantageous in connection with substances having an initial inclination to form large crystalline structures.

The crystal formation constituting the object of the present invention and the basis of my application No. 839,121 of even date is produced in passing a crystalline or a fibrous structure, through a short zone of intense heat, at a certain speed. In order to obtain a crystal of great length, the speed at which the wire or filament is passed through the hottest zone, must in any case, be equal to or less than the speed of growth of the crystal generated. If the process is carried out in this manner, the crystal generated in the hottest zone, and constituting the entire cross section of the filament will grow, by dissolving the on-coming or following crystals in proportion to the movement of the filament.

The crystal filament may be produced from any metal or alloys of metals as also from solid solutions of metals, particularly if the structure is of a large crystalline nature.

Advantageously very finely divided tungsten metal is employed, which has been evenly and intimately mixed with about 2%, more or less of thorium oxid. A mixture of these substances is particularly suitable for the formation of the crystal filament although, as stated other metals might be employed.

We have found that single crystals of the kind described are flexible and perfectly ductile. Furthermore wires of this kind possess the valuable property that the usual mechanical or thermic effects will not produce structural alteration or recrystallization of the same.

These wires are consequently an improvement on all wires produced mechanically, by drawing or rolling or on the known process of formation, because in connection with all known wires recrystallization appears in time and cannot be avoided permanently.

The advantages are particularly noticeable in connection with the employment of crystal wires as filaments for electric glow lamps, because they do not become brittle nor do they break either in making the lamp or in use, since no alteration of the structure takes place.

I claim as my invention:—

1. A metallic filament consisting of a single crystal throughout its whole length.

2. A metallic filament consisting of a single crystal throughout its whole length and cross section.

3. A tungsten filament composed of a single crystal.

4. A tungsten filament consisting of a single crystal elongated to any practicable length.

In testimony whereof I affix my signature in the presence of two witnesses.

OTTO SCHALLER.

Witnesses:

WOLDEMAR HAUPT,

HENRY HASPER.

1,256,930

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KAISERLICHES PATENTAMT

PATENTSCHRIFT

— № 283071

KLASSE 21 f. GRUPPE 34.

LIBRARY APR 26 1915 U. S. PATENT OFFICE
EINGEGANGEN DEN 26 MÄRZ 1915

FIRMA JOHANN KREMENEZKY IN WIEN.

Metallglühkörper für elektrische Glühlampen.

Patentiert im Deutschen Reiche vom 17. Januar 1914 ab.

Es ist schon vorgeschlagen worden, Metallglühkörpern, z. B. Wolframfäden, ob diese durch Ziehen oder durch Spritzen hergestellt wurden, hitzebeständige Fremdkörper, wie Calcium- oder Thoriumoxyd, in feiner gleichmäßiger Verteilung zuzusetzen, um die Rekristallisation der Glühkörper bei der hohen Erhitzung insbesondere durch Wechselstrom hintanzuhalten, der sie beim Gebrauch ausgesetzt sind. Auch ist bereits vorgeschlagen worden, für Elektrolytlampen, deren Glühkörper aus Borstickstoff besteht, oder für Glühlampen, deren Glühkörper neben Bor oder Silicium Borstickstoff bzw. Siliciumstickstoff enthalten, in die Birne eine Stickstoffatmosphäre einzubringen.

Gemäß vorliegender Erfindung wird Glühfäden aus hochschmelzendem Metall, wie Wolfram, eine geringe, 1 Prozent nicht übersteigende Menge Bor- oder Titanstickstoff einverleibt, wodurch die Rekristallisation verhütet, also erreicht wird, daß der Glühfaden selbst durch langandauerndes Glühen in der Lampe eine seine Lebensdauer nachteilig beeinflussende Änderung der Struktur nicht erfährt. Wohl aber kann dabei eine Änderung des Glühfadens in luftleerer Birne dadurch herbeigeführt werden, daß die Nitride sich zersetzen. Dadurch würde, ganz abgesehen vom Beschlagen der Birne, eine Änderung des Widerstandes des Fadens herbeigeführt werden. Um dies zu vermeiden, wird die Birne nicht luftleer gemacht, sondern mit Stickstoff gefüllt, wodurch die Dissoziation der Nitride hintangehalten wird.

Die Erzeugung solcher Glühkörper kann sowohl nach dem Pasteverfahren als auch nach dem Ziehverfahren erfolgen, jedoch ist es bei jeder Darstellungsweise empfehlenswert, das Sintern nicht, wie bisher üblich, in reinem Wasserstoff, sondern in Stickstoff oder in einem Stickstoff und Wasserstoff enthaltenden Gase, oder zuerst in Wasserstoff und dann in Stickstoff vorzunehmen, um einer Dissoziation des Nitrides vorzubeugen. Der mit Stickstoff behandelte Körper kann unmittelbar oder nach dem Ziehen zu Draht als Glühkörper Verwendung finden.

Selbstverständlich kann man statt aus Metall und Nitriden auch aus Metall und aus dem an den Stickstoff zu bindenden Element (z. B. Bor, Titan) des Nitrides die Paste oder Preßlinge erzeugen und die Überführung des betreffenden Elementes in das Nitrid in einem späteren Arbeitsabschnitte vornehmen, indem man das Gemenge von Elementen in einer Stickstoffatmosphäre erhitzt.

PATENT-ANSPRUCH:

Metallglühkörper für elektrische Glühlampen, dadurch gekennzeichnet, daß dem Metall eine 1 Prozent nicht übersteigende Menge von Bor- oder Titanstickstoff einverleibt ist, um die Rekristallisation beim Brennen der Lampe zu verhüten.

BERLIN. GEDRUCKT IN DER REICHSDRUCKEREI

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TRANSLATION

GERMAN PATENT N°. 283,071, issued March 25, 1915, to Firm of JOHANN KREMENEZKY in VIENNA

It has been proposed to add to metallic glowing elements, e.g., to tungsten filaments whether they are produced by the drawing or the squirting process, foreign heat-resistant bodies such as calcium or thorium oxide in finely and uniformly distributed form, whereby the recrystallization of the glowing element is prevented when it is heated to high temperatures, even when operated on alternating current. For electrolytic lamps having glowing elements composed of boron-nitride, or for lamps having elements containing boron or silicon-boron-nitride or silicon-nitride, it has been proposed to insert the filament in a bulb containing nitrogen atmosphere.

In accordance with the present invention the incandescent filament of high melting point metal such as tungsten contains also a small percentage, not in excess of 1%, of boron or titanium nitride, whereby recrystallization is prevented and even after prolonged burning the filament's structure will not be altered so as to shorten its life. However, the changing of the filament in evacuated bulbs can be brought about by the decomposition of the nitrides. Entirely disregarding the formation of a deposit on the bulb, this will alter the resistance of the wire. In order to obviate this the bulb is not evacuated but is filled with nitrogen, whereby dissociation of the nitride is prevented.

Such glowing elements can be produced either in accordance with the paste process or in accordance with the drawing process, but in all processes it is advisable to depart from the present practices and not carry out the sintering in pure hydrogen but in nitrogen, or in a gas containing nitrogen and hydrogen, or first in hydrogen and then in nitrogen, in order to prevent the dissociation of the nitride. The element which has been treated with nitrogen can then be directly or, after having been drawn into a wire, used as a glowing body.

Obviously, the paste or the ingots can be produced not only of the metal and nitrides, but also of the metal and of the elements which are to be combined with nitrogen as nitrides (e.g., boron or titanium). The transformation of the corresponding elements into the nitride is then effected in a later step by heating a quantity of these elements in a nitrogen atmosphere.

CLAIM -

Glowing metallic element for electric lamps characterised in that a quantity not in excess of 1% of boron or titanium nitride is incorporated in the metal in order to prevent recrystallization during the burning of the lamp.

fol. 413] In United States District Court, Eastern District of New York

Equity No. 7,723

General Electric Company, Plaintiff,

against

Wabash Appliance Corporation, Abe Adler and Abe M. Parker, Defendants

Howson & Howson, Solicitors for Plaintiff; Hubert Howson, Merrell E. Clark, Alexander C. Neave and John H. Anderson, of Counsel.

Darby & Darby, Solicitors for Defendants; Samuel E. Darby, Jr., and Paul Kolisch, of Counsel.

Opinion

Abruzzo, D. J.:

This is a suit for infringement of the Pacz patent No. 1,401,499, filed February 20, 1917, and issued March 21, 1922.

The patent contains claims covering a process and a product. However, only product claims 25, 26 and 27 are here in suit.

These three claims cover an incandescent lamp filament and read as follows:

"25. A filament for electric incandescent lamps or other devices, composed substantially of tungsten and made up [fol. 414] mainly of a number of comparatively large grains of such size and contour as to prevent substantial sagging and offsetting during a normal or commercially useful life for such a lamp or other device.

26. A drawn filament for electric incandescent lamps or other devices, composed substantially of tungsten and made up mainly of a number of comparatively large grains of such size and contour as to prevent substantial sagging and offsetting during a normal or commercially useful life for such a lamp or other device.

27. A filament for electric incandescent lamps or other devices, composed of tungsten containing less than three-fourths of one per cent of non-metallic material and made

up mainly of comparatively large grains of such size and contour as to prevent substantial sagging or offsetting during a normal or commercially useful life for such a lamp or other device."

The plaintiff contends that the filament covered by these claims represents an important advance in the art. The plaintiff and its licensees have undoubtedly sold billions of incandescent lamps embodying that filament. The defendants, Wabash Appliance Corporation, Abe Adler and Abe Parker, the latter two being the sole stockholders and officers of the corporate defendant, are not licensed under the Pacz patent.

The plaintiff charges the defendants with infringement in that the claim is made that the defendants make and sell electric incandescent lamps containing filaments which are in fact Pacz filaments of the claims in suit.

[fol. 415] The history of the incandescent lamp began about fifty years ago when Edison brought out the first commercial lamp that was successful. The Edison lamp contained a carbon filament and remained the standard of the industry until the advent of tungsten as a filamentary material.

Tungsten was disclosed in 1906 by the invention of Just and Hanaman. These tungsten filaments were of the squirted or pressed type, tungsten powder being mixed with a binding material in a plastic mass and then squirted under pressure through a die to a fine thread. It was then dried and sintered to form a filament of pure tungsten. Loops of this filament were then assembled on supports inside a glass bulb to form an incandescent filament (Pl. Ex. 8). This squirted tungsten filament was an improvement over the carbon filament but because this filament was a little brittle and weak it could not be made into large lengths or of accurate gauge.

While this tungsten filament was an improvement over the carbon lamp of Edison it, nevertheless, presented a problem known as "offsetting," which is the bodily shifting of a portion of the filament from an adjacent portion during the burning of the filament. These early tungsten filaments consisted of comparatively large crystals, many of which were large enough to extend clear across the filament, but they shifted. Because of the bodily shifting of portions of the filament (Pl. Ex. 12), the available cross

sectional area of the filament for carrying electric current was reduced at the point of the "offsetting." The filament then became overheated and burned out.

The next step in the history of the filament was the [fol. 416] Coolidge patent 1,082,933. His method of making the drawn tungsten filament included means for preventing "offsetting". Since "offsetting" was known to occur when, as Coolidge put it (Pl. Ex. 2), the crystals became "so large as to extend across the entire section of the filament," Coolidge made provision (by the addition of certain chemical materials at an early stage of his process) for arresting crystal growth in the final filament. His theory was the maintenance of a small crystal structure. He did not have large crystals so as to extend the entire section of the filament. As a result of his method his filament was a non-offsetting filament.

The Coolidge method was, of course, a great improvement over the weak squirted filament. Its grains were so small and numerous that none extended all the way across the filament, which prevented slipping and in turn this made a non-offsetting filament. However, there was another serious defect characteristic of a tungsten filament. This was the defect of "sagging."

The Coolidge patent did not take care of the problem of "sagging." The filament in a lamp is not stiff enough to support itself and consequently must be strung between supports. The Coolidge filament would sag between its supports after use for some time.

"Sagging" deformed the filament from the position it was supposed to maintain and it would also reduce the efficiency of the lamp in time, causing its failure. This was a definite problem in the art. It was not solved by Coolidge. A large number of supports were used as a remedy but this did not eliminate "sagging."

The problem presented to Pacz was to make a practical [fol. 417] filament that would neither "offset" nor "sag." Pacz knew, like the others in the art, if the grains were allowed to grow the filament would "offset." If grain growth were prevented, like the Coolidge method, the filament would not "offset" but would "sag." The art taught one to avoid large grains since that would allow "offsetting." The problem remained unsolved until Pacz made the invention of the patent in suit.

Until the advent of this Pacz filament the state of the art, undoubtedly, was such that experiments were being made in order to produce a filament that would not "sag."

The defendants have cited many patents as a defense to the one in suit and make a further claim that the Pacz patent did not improve the art existing at the time of the granting of his patent. These patents cited by the defendants can readily be distinguished.

To determine whether the insoluble problem was in fact solved by Pacz can easily be determined. Pacz made a multi-crystal filament having grains of large size to prevent "sagging" and of such contour that even though the boundary between grains extended all the way across the filament, no slippage or "offsetting" occurred. Pacz was able to control the contour or shape of the grains so that they did not slip. He had had 217 failures and was finally successful on his 218th attempt. For that reason the filament is frequently referred to by number 218. This 218 filament, like the Coolidge filament, was drawn tungsten and was made in much the same way as that described by Coolidge. The difference between the Pacz filament and [fol. 418] the Coolidge filament was that Coolidge overcame "offsetting" by adding small amounts of certain chemical materials at an early stage of the process which insured the maintenance of small grains in the final filament, while Pacz employed different chemical materials which produced the opposite effect of promoting in the final filament the growth of large grains of such contour that not only did it prevent "offsetting," as in the Coolidge filament, but solved the problem of "sagging."

The theory of Pacz was directly contrary to the prior teachings. The Pacz filament never produced a crystal boundary joining large crystals which were either disposed in the right position to "offset" or which were smooth, easily permitting the movement of one crystal away from the other. He produced large crystals not late in the burning life of the lamp but very early, obtaining a coarse-grained filament which did not "offset" and since the filament was coarse-grained it did not "sag."

As the structure of the filament under the Pacz method is comparatively coarse-grained, this was the reason given by Pacz why the filament did not "sag." However, that would mean to the art that the filament would "offset" be-

cause it was common knowledge in the art that where grain boundaries, large enough to extend across the filament, were produced there would be bound to be slippage. Under the Pacz patent it is claimed that a particular kind of coarse-grained filament is produced which does not "offset." These coarse-grained boundaries are of such a nature that they prevent slipping action. The contour of these grains [fol. 419] by the method used by Pacz is a very important element. Pacz found that he produced such a filament by the method disclosed in his patent in which a material intimately associated with the tungsten particles has an effect on the shape and size of the tungsten grains. The material which Pacz used for producing the desired result was an Alkali silicate.

It is conceded by the plaintiff that no one knows even at the present time just why the Pacz process should make grains of such a size that the filament will not "sag" and of such a shape that the grains will not slip and produce "offsetting" (Pl. Brief, p. 11).

The claims now in suit were held valid by the Circuit Court of Appeals, Ninth Circuit, 80 F. (2d) 958, which affirmed the decision of the United States District Court for the Southern District of California, 10 F. Supp. 935, in the case of General Electric Co. v. Anraku. A petition for writ of certiorari to the United States Supreme Court was denied, 80 Law. Ed. 959.

The opinion of the Ninth Circuit Court of Appeals sustained the claims of the patent now in suit in spite of the defenses interposed in that action, many of which are before the Court in this case.

The first proposition that the defendants advance is that the Pacz product does not constitute a patentable invention. The defendants further claim that Pacz did not describe his invention in such full, clear and exact terms that anyone skilled in the art, subsequent to the expiration of the patent grant, could make the patented device solely from the information contained in and disclosed by the patent [fol. 420] and cites the case of General Electric Company v. DeForest, 17 F. (2d) 90, in support of this proposition. The cited case involved the Coolidge patent. In the Coolidge case, the product claims defined the article by characteristics and not by structure. Claim 25 of the Pacz patent specifies that there shall be a number of grains and that

they shall be comparatively "large" and of such "size" and "contour" as to prevent substantial "sagging and offsetting." This made a new structure. It is patentable as a product quite apart from the process. Dunn v. Toronto, 259 Fed. 258 (C. C. A. 6).

There was no novelty alone in the product of a sagless filament, but there was in one of a particular structure having a number of large grains, multi-grained and of a special contour. This was new and novel to the art and clearly distinguished the Schaller patent which had a single crystal filament that was sagless but a failure.

Secondly, the defendants claim that a valid patent cannot be granted by the government unless the claims of the patent are in such clear and precise terms that the public, during the life of the patent, may know what is excluded from it and what is vested in the patentee, defining the boundary lines of the monopoly of the patent clearly.

There is ample proof that the plaintiff's present commercial process does use the Pacz method as defined in its patent and produces not only a non-offsetting filament but also a sagless filament. Millions of lamps containing a filament having the Pacz structure are being sold to the public and the structure is new and novel to the art and is therefore patentable. The defendants' witness, Mr. Laise, [fol. 421] admitted that defendants' exhibit KK was commercially a non-sagging and non-offsetting filament as was defendants' exhibit LL (Rec. p. 375).

There is a sufficiency of disclosure and the claims are so clearly set forth that one skilled in the art would have no difficulty in making a Pacz filament. The defendants set forth the rule laid down by Judge Learned Hand, speaking for the Court of Appeals for the Second Circuit, in Health Products Corp. v. Ex-Lax Manufacturing Co., 22 F. (2d) 286, 287, in which he stated:

"It is scarcely necessary to labor the principle that specifications must be more than a suggestion for promising experiment, hit or miss. They must contain complete directions, leading with certainty to the result."

The defendants' wire is undoubtedly a Pacz filament. Both the plaintiff's and the defendants' filaments are drawn, they are both made of tungsten, they both have less than three-fourths of one per cent. non-metallic material,

they consist of a number of comparatively large grains so as to prevent sagging and the grains are of such contour and shape so as to prevent offsetting.

Dr. Jeffries called by the plaintiff frankly and with no intention to deceive the Court stated the formula of materials which made up the Pacz filament. On the other hand, the defendants' witness, Mr. Laise, when called upon to state the formula of materials used by the defendants, refused to reveal the secret of the manufacture of the defendants' filament. This could not be merely a coincidence [fol. 422] or accidental and in itself answers the argument of the defendants that the plaintiff's patent is invalid because of insufficiency of disclosure. The disclosure was certainly sufficient so that the defendants could copy same.

As to the defendants' claim that the plaintiff does not use the present commercial process of the Pacz patent, suffice it to say that the evidence clearly indicates and shows that the filament 218 is made directly pursuant to the claims. The materials used in making this Pacz filament are easily understandable to one skilled in the art. They were apparently imitated without trouble by the makers of the defendants' filament.

The defendants claim that the plaintiff's process will not produce a sagless filament. The evidence showed that what the manufacturers of filaments were trying to make was a commercially sagless filament. Many of the lamps, containing the Pacz filament, were burned for demonstration purposes before the Court and from all of these tests, the Court is convinced beyond any doubt that the Pacz 218 wire makes a commercially sagless filament. This is particularly obvious when a comparison is made between the Coolidge filament and the Pacz filament.

At the time these demonstrations were made, the Coolidge filament sagged to some extent while the Pacz filament and the defendants' filament did not sag.

The defendants' expert, Mr. Laise, admitted that the defendants' filaments were commercially non-sagging (Def. Ex. KK and LL, supra. A great deal of finely spun language was used by the witness in describing the action of the [fol. 423] different filaments in evidence but the demonstrations as seen by the Court were proof that could not be questioned and the interpretation to be placed on the action of the filament as seen by the Court could hardly be described as well by words or language.

That the burning of these filaments before the Court indicated unquestionably that the Pacz patent differed from the prior art in a great degree could be clearly ascertained by these demonstrations. The lamps containing the Coolidge filaments as stated before could be seen to "sag" slowly but surely, while the Pacz and defendants' filaments did not react that way. Pacz must have, in 218 experiments, utilized a great deal of time and energy to gain the objective which his filament obtained. Undoubtedly, all other manufacturers of filaments were striving to gain the same end.

"Sagging" was a definite problem in the art up to the advent of the Pacz filament. It is conceded that "sagging" destroys the longevity of the filament which in turn would destroy the commercial aspects of the filament. The Pacz filament assisted materially in the commercial success of that filament and differs from the prior art to a great degree because of its structure. The making of the Pacz filament could hardly be said to be carrying forward a new or more extended application of the original thereof. It was not a change in form only to some degree but the tests showed a marked change in the "sagging" problem of the Pacz filament as against the "sagging" of the other filaments prior to the Pacz patent. Pacz accomplished by his invention something different in principle and in kind from [fol. 424] the prior art and did so in the face of the contrary teaching contained in the Coolidge patent.

The Schaller patent, as already indicated, taught the world to keep away from multi-grained filaments because they could not be controlled. The patent in suit taught the opposite theory. It has been proved that the Schaller patent was not a success commercially or otherwise and taught the art nothing of a substantial nature. Certainly, it did not teach the theory contained in the Pacz patent.

The Scoular patent represents one of the squirted filaments and to make same one has to use some type of binder for the tungsten powder. There is no mention in that patent of "sagging" or "offsetting." The Scoular wire was swaged and drawn (Rec. p. 416) and the filament did "offset" (Rec. p. 415).

The Kruger patent did not solve the problem confronting the art. It does not mention "sagging" or "offsetting," or large crystals or the use of an alkali silicate.

The Kremenzky German patent, about which no testimony was offered by the defendants, seems particularly directed to the squirting method.

"Die Welt der Technik," a German publication (Def. Ex. HHH), which was introduced without testimony, speaks of the problem of "offsetting" but contributes nothing of interest concerning its solution.

The defense that the Pacz patent is invalid because of double patenting is predicated on the prior Pacz patent 1,299,017, granted April 1, 1919, on application filed May [fol. 425] 25, 1914, three years before the Pacz patent in suit was applied for. There is also cited a prior use and sale of the Pacz filament in suit. The Westinghouse Company did sell in 1911 or 1912 a filament which contained four different binders, but the testimony is not clear which one of the binders was used at any time, nor was any of this wire nor any of the lamps with the wire produced into evidence. Certain exhibits were offered in evidence during Mr. Cowles' testimony but his indefiniteness as to the size of the filament and as to the magnification of the picture left the matter very hazy. This same witness stated that he was in the employ of the Independent Lamp Co., from 1912 to 1920, during which time he was making experiments but there is no testimony as to any prior sale or use by this Independent Lamp Co.

If there were double patenting, it would be based on the proposition that a patentee can have but one patent for a single invention as found in Miller v. Eagle Manufacturing Company, 151 U. S. 186, but this has not been established here.

Pacz, in his earlier patent, followed the same theory as Coolidge which indicated that the only way to prevent "offsetting" in a multi-grained filament was to avoid coarse grains and insure a finely granular structure. In his early patent, Pacz stated as follows:

"If the cross-section is shiny or shows coarse grains the filament will offset. On the other hand, if the structure is finely granular, the filament will not offset. Rods produced from the metal, as above described, when subjected to this [fol. 426] test had cross-sections which were finely granular."

It will be readily seen that the Pacz patent in suit is distinctly different from the earlier one. The structure ob-

tained by the first patent of Pacz was nothing like the one obtained in the second Pacz patent. Therefore, there was no double patenting within the meaning of the law.

That the Pacz patent was infringed is clearly indicated by the evidence on the trial. The tests of the Pacz filament and the defendants' filament prove conclusively that the filaments were one and the same. It is unavoidable to arrive at the conviction that the defendants' filament was made exactly as was the plaintiff's. The microphotographs showed that the defendants' filament was made exactly like the plaintiff's. The qualities of the filaments were as alike as "two peas in a pod" and the burning tests in open Court proved that the two filaments were twins. The testimony showed that they were both drawn, both were made of tungsten, both had less than three-fourths of one per cent. of non-metallic materials, both consisted of a number of large grains, large enough to prevent sagging and offsetting in spite of the fact that they extended clear across the filament (Rec. pp. 249-250).

In disposing of some of the defenses interposed by the defendants, the Court can hardly refrain from stating that "imitation is the sincerest form of flattery." The defendants surely must think that the plaintiff's filament is an excellent one or they would not have made theirs exactly like it. When the defendants' expert, Mr. Laise, declined to divulge to the Court, the formula of the filament manu- [fol. 427] factured by the defendants, the conclusion reached by the Court was that the defendants were neither sincere nor frank. No sensible explanation for this refusal was given in spite of the fact that testimony revealed that the plaintiff's wire and the defendants' wire were made exactly alike. The expert for the defendants testified that the defendants' filament was not made similar to the plaintiff's wire but refused to tell in what particular or manner it was made different from that of the plaintiff. (Rec. pp. 464, 465, ques. 281-289, inclusive.)

The defendants Wabash Appliance Corporation and the individuals Adler and Parker are one and the same. The acts of the corporation are the acts of the individuals and the individuals are liable for the corporate acts of the corporation. This rule is clearly laid down by Judge Manton in Claude Neon Lights v. American Neon Light Corp. (C. C. A. 2), 39 F. (2d) 548.

Accordingly, the plaintiff may have a decree for injunction and accounting.

Matthew T. Abruzzo, U. S. D. J.

January 16, 1937.

[fol. 428] In United States District Court

[Title omitted]

Stipulation as to Findings of Fact and Conclusions of Law

It is stipulated and agreed that the opinion of the Court on final hearing in this case may be taken as a sufficient compliance with Equity Rule 70½ and the Rules of this Court with regard to findings of fact and conclusions of law.

Howson & Howson, Solicitors for Plaintiff. Darby & Darby, Solicitors for Defendants.

February 4th, 1937.

[fol. 429] In United States District Court, Eastern District of New York

Equity No. 7,723

General Electric Company, Plaintiff,

against

Wabash Appliance Corporation, Abe Adler and Abe M. Parker, Defendants

Interlocutory Decree

This case having come on for trial on bill and answer, and proofs having been submitted on behalf of the plaintiff and of the defendants, and the Court having duly considered the case, it is

Ordered, Adjudged and Decreed, as follows:

1. That Letters Patent of the United States of America in suit No. 1,410,499, issued under date of March 21, 1922, to the plaintiff, General Electric Company, as assignee of Aladar Pacz, for Metal and Its Manufacture, are good and valid in Law as to claims 25, 26 and 27 thereof;

2. That the plaintiff, General Electric Company, is the owner of said Letters Patent and of all rights thereunder and has been such since the grant thereof;

3. That said defendants Wabash Appliance Corporation, Abe Adler and Abe M. Parker have jointly and severally in- [fol. 430] fringed upon claims 25, 26 and 27 of said Pacz patent by the manufacture, use and/or sale of incandescent electric lamps containing and embodying the invention of said claims of said Letters Patent;

4. That a perpetual injunction issue out of and under the seal of this Court enjoining and restraining the said defendants Wabash Appliance Corporation, Abe Adler and Abe M. Parker, their officers, directors, agents, attorneys, workmen and employees and all persons in privity with them or any of them, from infringing upon claims 25, 26 and 27 of said Pacz Letters Patent 1,410,499, reading as follows:

"25. A filament for electric incandescent lamps or other devices, composed substantially of tungsten and made up mainly of a number of comparatively large grains of such size and contour as to prevent substantial sagging and offsetting during a normal or commercially useful life for such a lamp or other device.

26. A drawn filament for electric incandescent lamps or other devices, composed substantially of tungsten and made up mainly of a number of comparatively large grains of such size and contour as to prevent substantial sagging and offsetting during a normal or commercially useful life for such a lamp or other device.

27. A filament for electric incandescent lamps or other devices, composed of tungsten containing less than three-fourths of one per cent of non-metallic material and made [fol. 431] up mainly of comparatively large grains of such size and contour as to prevent substantial sagging or offsetting during a normal or commercially useful life for such a lamp or other device."

or any of said claims in any way whatsoever and more particularly from directly or indirectly making or causing to be made, using or causing to be used, selling or causing to be sold, in any manner, any lamps or other devices or apparatus, containing or embodying the improvements described and claimed in said claims of said Letters Patent, or

any of them and from inducing others to make, use or sell, such infringing lamps or other devices or apparatus in any way whatsoever within the territory covered by said Letters Patent.

5. That the plaintiff do recover of the said defendants all of the profits, gains and advantages which the said defendants have derived, received, earned, made or saved by reason of said infringement, and the damages which plaintiff has sustained by reason of said infringement; and it is hereby referred to Frank McGarry, 51 Chambers Street, New York City, as Master of this Court, to take and state an accounting of said profits, gains and advantages and damages, and report the same to the Court; that before entering upon the exercise of his duties as such, the Master shall file an oath as prescribed by law; and that the question of increase of damages be reserved until the coming in of the Master's report;

[fol. 432] 6. That the plaintiff do recover of the defendants its costs and disbursements in this suit to be taxed by the Clerk.

Matthew T. Abruzzo, United States District Court.

February 5th, 1937.

Asented to as to form. Darby & Darby, Attorneys for Defendant.

IN UNITED STATES DISTRICT COURT

[Title omitted]

PETITION FOR APPEAL

The above named defendants, conceiving themselves aggrieved by the interlocutory decree made and entered herein on the 5th day of February, 1937, do hereby appeal from the [fol. 433] said decree to the United States Circuit Court of Appeals for the Second Circuit for the reasons specified in the Assignment of Errors filed herewith; and they pray that this appeal be allowed and that a Citation be issued, as provided by law, directed to the above named plaintiff, General Electric Company, commanding it to appear before the United States Circuit Court of Appeals for the Second Circuit to do and receive what may appertain to justice to be

done in the premises; and that a transcript of the record, proceedings and papers upon which said decree was made, duly authenticated, together with such original matters as cannot be reproduced, be sent to the United States Circuit Court of Appeals for the Second Circuit; and your petitioners further pray that the proper Order as to the security to be required of it to perfect this appeal be made.

Wabash Appliance Corporation, Abe Adler, and Abe M. Parker, by Darby & Darby, Their Attorneys.

Dated, New York, N. Y., February 15, 1937.

[fol. 434] In United States District Court

[Title omitted]

Order Allowing Appeal

And now to wit: this 15th day of February, 1937, upon consideration of the Petition for Appeal filed herein by defendants, it is

Ordered, that the appeal of the said defendants prayed for therein be and hereby is allowed and the amount of the appeal bond to be entered by appellants is hereby fixed in the sum of Two Hundred Fifty Dollars ($250.00).

Matthew T. Abruzzo, U. S. D. J.

Dated February 15, 1937.

[fol. 435] In United States District Court

[Title omitted]

Assignment of Errors

Now come Wabash Appliance Corporation, Abe Adler, and Abe M. Parker, defendants herein, and present with their accompanying Petition for Appeal from the Interlocutory Decree made and entered in this cause on the 5th day of February, 1937, the following Assignment of Errors:

1. The District Court erred in holding claims 25, 26 and 27 of Pacz patent No. 1,410,499, valid and to have been infringed by defendants.

2. The District Court erred in failing to hold claims 25, 26 and 27 of Pacz patent No. 1,410,499, to be invalid.

3. The District Court erred in failing to hold claims 25, 26 and 27 of Pacz patent No. 1,410,499, to be invalid because of the absence of inventive act for the product claimed thereby distinct from the process by which the product was made.

[fol. 436] 4. The District Court erred in failing to hold claims 25, 26 and 27 of Pacz patent No. 1,410,499, to be invalid because of insufficiency of disclosure.

5. The District Court erred in failing to hold claims 25, 26 and 27 of Pacz patent No. 1,410,499, to be invalid because of indefiniteness of the claims.

6. The District Court erred in failing to hold claims 25, 26 and 27 of Pacz patent No. 1,410,499, to be invalid because they differ from the prior art only in a degree of an unpatentable nature.

7. The District Court erred in failing to hold claims 25, 26 and 27 of Pacz patent No. 1,410,499, to be invalid because of anticipation by and want of invention over the prior art.

8. The District Court erred in failing to hold claims 25, 26 and 27 of Pacz patent No. 1,410,499, to be invalid because of prior knowledge and use.

9. The District Court erred in failing to hold claims 25, 26 and 27 of Pacz patent No. 1,410,499, to be invalid because of double patenting.

10. The District Court erred in holding that claims 25, 26 and 27 of Pacz patent No. 1,410,499, were infringed by defendants.

11. The District Court erred in failing to hold that the defendants' products were free of infringement of claims 25, 26 and 27 of Pacz patent No. 1,410,499.

12. The District Court erred in granting an injunction and an accounting in this cause.

[fols. 437-438] 13. The District Court erred in failing to dismiss the bill of complaint.

14. The District Court erred in basing its opinion and decree, in whole or in part, upon an alleged refusal of a witness to disclose current trade secrets and in actually or by inference attributing relevancy thereof to the issues in this case.

Wabash Appliance Corporation, Abe Adler, and Abe M. Parker, by Darby & Darby, Their Attorneys.

Dated, New York, N. Y., February 15, 1937.

Citation, in usual form, showing service on Howson & Howson, omitted in printing.

[fol. 439] In United States District Court

[Title omitted]

Stipulation as to Contents of Record

It is Hereby Stipulated and Agreed, that the true transcript of the record for the purpose of appeal from the decree made and entered herein on February 5, 1937, by the United States District Court for the Eastern District of New York, shall contain:

1. Bill of complaint filed August 26, 1935.
2. Defendant's answer filed as of October 14, 1935.
3. Narrative statement of evidence at trial.
4. Plaintiff's Exhibits 1, 2 and 14.
5. Defendants' Exhibits A, B, L, M, R, S, CCC.
6. Opinion of Court with stipulation as to the Court's findings of fact and conclusions of law.
7. Decree.
8. Petition for appeal.
9. Assignment of errors.
10. Order allowing appeal.
11. Citation.
12. This stipulation.
13. Stipulation as to correctness of printed record.

[fol. 440] 14. The Clerk's certificate.

It is Further Stipulated and Agreed, that the following Exhibits are to be treated as physical exhibits and produced in Court at the argument of the appeal.

1. Plaintiff's Exhibits 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32 and 33.
2. Defendants' Exhibits C, D, E, F, G, H, I, J, K, N, O, O-1, P to P-3, Q, T, U, V, W, X, Y, Z, AA, BB, CC, DD, EE, FF, GG, HH, JJ, II, KK, LL, MM, NN, OO, PP, QQ, RR, SS, TT, UU, VV, WW, XX, YY, ZZ, AAA, BBB, DDD, EEE, FFF, GGG, HHH.

Howson & Howson, Attorneys for Plaintiff. Darby & Darby, Attorneys for Defendants.

Dated: March 4, 1937.

It is Ordered by the Court, that the foregoing stipulation be and hereby is approved, and the Clerk is hereby authorized to certify the transcript of record on appeal prepared in accordance therewith.

Matthew T. Abruzzo, D. J.

March 6, 1937.

[fol. 441] In United States District Court

[Title omitted]

Stipulation as to Record

It is hereby stipulated and agreed, that the foregoing is a true copy of the transcript of the record of the said District Court in the above-entitled matter as agreed on by the parties.

Dated, April —, 1937.

Howson & Howson, Attorneys for Plaintiff. Darby & Darby, Attorneys for Defendants.

On reading the foregoing consent of the attorneys for the respective parties herein, It is Ordered, that the foregoing printed record be filed in lieu of the original papers for the purpose of certifying a record on appeal.

Dated, April —, 1937.

—— ——, U. S. D. J.

[fol. 442] Clerk's certificate to foregoing transcript omitted in printing.

[fol. 443] In United States Circuit Court of Appeals for the Second Circuit

General Electric Company, Plaintiff-Appellee,

vs.

Wabash Appliance Corporation, Abe Adler and Abe M. Parker, Defendants-Appellants

Before Manton, Swan and Augustus N. Hand, Circuit Judges

Appeal from the District Court of the United States for the Eastern District of New York

From an interlocutory decree holding valid and infringed claims 25, 26, and 27 of Patent No. 1,410,499 to Adam Pacz, assignor to the plaintiff, the defendants have appealed. Decree reversed.

For opinion below see 17 F. Supp. 901.

Darby & Darby, Solicitors for Appellants; Samuel E. Darby, Jr. and Paul Kolisch, of Counsel.

Howson & Howson, Solicitors for Appellee; Hubert Howson, Merrell E. Clark, Alexander C. Neave and John H. Anderson, of Counsel.

Opinion—Filed August 16, 1937

Swan, Circuit Judge:

This is a patent infringement suit based on the Pacz Patent No. 1,410,499, owned by General Electric Company. [fol. 444] The patent issued March 21, 1922, on an application filed February 20, 1917. It relates to tungsten filaments for incandescent lamps, and contains both process and product claims; but only product claims are involved in the present litigation. The defendants are charged with selling lamps having filament (purchased by them for as-

semblage into lamps) which infringes claims 25, 26 and 27 of the patent. The two individual defendants are the sole officers and stockholders of the corporate defendant.

It will suffice to quote one of the three claims in suit. Claim 25 reads as follows:

"25. A filament for electric incandescent lamps or other devices, composed substantially of tungsten and made up mainly of large grains of such size and contour as to prevent substantial sagging and offsetting during a normal or commercially useful life for such a lamp or other device."

Claim 26 differs only in specifying that the filament shall be "drawn", and claim 27 in requiring the tungsten to contain "less than three-fourths of one per cent. of non-metallic material."

Concededly there was no novelty, when Pacz filed his application, in a filament, either pressed or drawn, composed substantially of tungsten. His advance, if any, over the prior art consisted in forming the grains or crystals "of such size and contour as to prevent substantial sagging and offsetting" during the normal life of a lamp in use. The filament of an electric incandescent lamp is a fine thread of conducting material which gives light by becoming incandescent. It is not stiff enough to support itself and must be strung between supports within the bulb. The heat to which the filament is subjected during operation of the lamp tends to deform it and cause it to sag between [fol. 445] its supports. The specifications state that the object of the invention is "to produce tungsten metal which will retain to a much higher degree than heretofore its original properties after being subjected to high temperatures"; that in the case of incandescent lamp filaments the high temperatures at which they are run have caused them to elongate and sag between their supports, especially coiled filaments in gas filled lamps, and this tends to reduce the efficiency of the lamp; that "by means of my invention the sagging is substantially eliminated and 'offsetting' of the filament is substantially prevented, during a normal or commercially useful life of the lamp". Parenthetically we depart from the specifications to explain that "offsetting" refers to a lateral shifting of a portion of the filament from an adjacent portion—like a slip at a geological fault line. The result is to reduce the cross-sectional area of the fila-

ment between the offset portions, causing it more readily to burn out or break. Offsetting takes place along the boundary lines between adjacent crystals during the heating of the filament in use. If the boundaries are perpendicular to the axis of the filament and extend across its width, offsetting is more serious than if the crystals are small or of irregular contour. We now return to the specifications. They continue with the statement that the inventor brings into intimate association with tungsten a material which will have the desired influence upon the grain growth of the metal, and will be removed by volatilization during the sintering of the metal. It is explained that the presence of this material intimately associated with the tungsten particles "has a marked effect on the shape and size of the tungsten grains"; that the probable reason why filaments made according to the invention do not sag is that "the structure is comparatively coarse grained"; and [fol. 446] that the coarse grained filament produced by means of the invention "does not 'offset' so as to cut short the life of the lamp appreciably". The remainder of the specifications deal with the patentee's process, which need not be described for present purposes further than to say that the preferred material which is brought into intimate association with the tungsten is an alkaline silicate.

The problems of sagging and offsetting were recognized long before Pacz entered the field, and efforts had been made to overcome them by adding beneficial ingredients to pure tungsten. The Coolidge Patent No. 1,082,933, issued December 30, 1913 to the plaintiff as assignee, and to which the patent in suit refers, taught how to make a tungsten filament which was as satisfactory in respect to offsetting as is the product of the Pacz patent. Although conceding that the Coolidge filament was non-offsetting, the plaintiff contends that it was fine-grained and therefore necessarily a sagging filament. The patents to Schaller, issued in 1918 on applications filed in 1914, taught the production of a filament consisting of a single crystal throughout its whole length. This prevented both sagging and offsetting, but the method was too costly for general acceptance by the trade and found practical use only in small types of lamps, such as flash light and Christmas tree lamps. In 1915 Kruger obtained a process patent for the production of tungsten filaments with a boron compound, which the defendant contends produced a non-sagging and non-offsetting

filament because Pacz had so asserted in the patent in suit—a statement disclaimed by the plaintiff in 1933. Pacz himself, in a prior patent, No. 1,299,017 issued April 1, 1919, to the plaintiff as assignee, taught a process, very similar [fol. 447] to that of the patent in suit, for producing a filament which "showed no offsetting after continued use" and of which the coils "retained their shape to a very high degree after continued use" (page 1, ls. 98-103). Thus it is apparent that the Pacz patent in suit was not a pioneer patent in respect to non-sagging and non-offsetting filament. What is claimed for the product of the patent in suit is that it does not sag as much as the multi-grained filaments of the prior art; in other words it is urged that under the patent in suit Pacz was the first to produce a multi-grained filament having crystals large enough to prevent substantial sagging and of such irregular contour that, even though they extended completely across the filament, no substantial offsetting between their boundaries would occur during the normal life of the lamp.

The defendants first contend that the product claims in suit are invalid on their face for insufficiency and indefiniteness of disclosure. In each of the claims the element which purports to distinguish the Pacz product from the products of the prior art is described by the statement that the filament is "made up mainly of comparatively large grains of such size and contour as to prevent substantial sagging and offsetting during a normal or commercially useful life for such a lamp". In the specifications the grains are characterized, without basis of comparison, as "comparatively coarse", but their size and contour are otherwise left indeterminate except as tested by the behavior of the filament during operation, which test is also indefinite, since the phrase "substantial sagging and offsetting" is not defined. Hence it is argued that the public cannot know what degree of sagging or of offsetting is within and what degree without the plaintiff's asserted monopoly. Cf. Permutit v. Graver [fol. 448] Corp., 284 U. S. 52, 60; Kwik-Set, Inc., v. Welch Grape Juice Co., 86 F. (2d) 945, 947 (C. C. A. 2); National Theatre Supply Co. v. Da-Lite Screen Co., 86 F. (2d) 454 (C. C. A. 7); Therm-O-Proof Insulation Co. v. Slayter & Co., 80 F. (2d) 557, 559 (C. C. A. 7). In view of the difficulty, if not impossibility, of describing adequately a number of microscopic and heterogeneous shapes of crystals, it may

be that Pacz made the best disclosure possible, although it would appear that he could have expressed in millimeters what he meant by "substantial sagging". The testimony is that a filament which sags not more than 5 mm. is a commercially "non-sagging" filament. However, the process of the patent is adequately described so that one may follow it, and if the product claims be read to mean a substantially (i. e. a commercially useful) non-sagging and non-offsetting filament having a grain structure such as is produced by following the process of the patent, they would seem to be sufficiently definite to inform the public of the limits of the monopoly asserted with respect to the product. The same three claims were sustained against a similar contention in Anraku v. General Electric Co., 80 F. (2d) 958 (C. C. A. 9), cert. denied 298 U. S. 678. Because the appeal is to be determined on another point, we may assume, without the necessity of deciding, that the claims are not invalid for insufficiency or indefiniteness of disclosure.

The defendants further contend that the claims in suit are invalid because of anticipation by the prior art and want of invention. Their chief reliance is the Coolidge patent No. 1,082,933, to which reference has already been made. The filament produced by the Coolidge process was admittedly a non-offsetting filament, and the defendants maintain that they have proved it to be as much a non-[fol. 449] sagging filament as is the filament produced by the Pacz process. It may be remarked parenthetically that the plaintiff put in evidence no filament made in strict conformity with the process of the patent in suit. Since 1921 the plaintiff in its commercial production has made numerous changes from the process outlined in the patent, and only samples of its present commercial product were put in evidence. Of course, it is the product of the patent, not the plaintiff's commercial product, with which comparisons must be made. Dr. Jeffries, however, explained that the changes were made to obtain a more uniform commercial production and did not depart from the principles of the patent nor produce a different filament but only a greater percentage of the coarse-grained sagless filament than had been obtained from an exact following of the patented process. Coolidge described two methods of making his filament material. His preferred method heated purified tungstic oxid in a covered Hessian or Battersea crucible,

"after which step it is found to be coarser and of higher density and to contain matter, probably volatilized from the crucible * * *" consisting largely of alumina and silica (page 2, ls. 74-84). His other method was to mix with tungsten powder certain refractory material such as oxids of thorium. To show that Coolidge's filament was fine-grained and one that would sag, the plaintiff introduced samples of thoriated tungsten filament. Such proof was good so far as it went, but it was not proof as to the structure of the filament produced according to Coolidge's preferred Battersea crucible treatment. This is likewise true of the microphotographs and expert testimony introduced by the plaintiff, none of which was directed to establishing that the Battersea filament was fine grained or prone to sag. It is true that [fol. 450] Coolidge taught the retardation of crystallization in order to prevent offsetting, while Pacz teaches the growth of crystals to prevent sagging and the formation of crystals of irregular contour to prevent offsetting. But what Coolidge taught is immaterial with respect to the product claims in suit if the product of his Battersea treatment was in fact the same as that described in the claims in suit, for in that event the product so claimed was not new. If the addition of an alkaline silicate—as little as one-twentieth of one per cent will suffice, Pacz says—has the effect of producing grain growth in the Pacz filament, it is argued by the defendants that it must have had a similar effect in the Coolidge Battersea filament. The only proof of the structure of the Battersea filament is that offered by the defendants. They put in evidence as Exhibit K microphotographs of filaments produced by strictly following Coolidge's Battersea method. Of the three lots of which samples were photographed, all showed grains large as compared with those of a thoriated filament; and two of the three showed a sag of only two millimeters after more than 100 hours burning. Dr. Jeffries, the plaintiff's expert, had testified that a sag up to five millimeters was permissible for the Pacz filament. Thus, two of the three filaments shown on Exhibit K were substantially non-sagging. Moreover, the crystals were comparable in size and shape to those resulting from following the Pacz process. When this exhibit was first shown to Dr. Jeffries, and before he knew what filament it represented, he testified (fol. 429):

"If one were judging from those two microphotographs alone, in the very restricted length shown and could be absolutely assured that the rest of the length of the filament [fol. 451] has the same grain contour and the same grain size, the two micrographs could be described as representative of non-sag and non-offsetting Tungsten filament."

On rebuttal Dr. Jeffries testified that lot N-991 was a sagging structure because of the fine grain, and that lot N-989 would be a reject lot under the Coolidge process. But he admitted he had had no experience in the manufacture of Coolidge filaments under the Battersea treatment, and his assertions, supported by no tests, that the filaments of Exhibit K must have sagged because Coolidge taught the production of fine grained filaments, cannot override the positive testimony of the defendants' witnesses that these filaments were produced in exact conformity with the Coolidge Battersea process and sagged only 2 mm. after 100 hours of burning. Cowles and Laise testified to the production by the companies by whom they were employed of great quantities of the Battersea filament which was commercially non-sagging. The Battersea treatment did not produce uniform lots, some sagged greatly, others only a little. The Pacz process gives more uniform production. But in so far as the patent in suit claims a new product, we think the claims in suit were anticipated by filament produced by the Coolidge Battersea crucible treatment.

This result makes unnecessary a consideration of the other grounds of defense.

The decree is reversed with directions to dismiss the bill of complaint.

[File endorsement omitted.]

[fol. 452] In United States Circuit Court of Appeals, Second Circuit

Present: Hon. Martin T. Manton, Hon. Thomas W. Swan, Hon. Augustus N. Hand, Circuit Judges.

General Electric Company, Plaintiff-Appellee,

vs.

Wabash Appliance Corporation et al., Defendants-Appellants

Judgment—Filed August 23, 1937

Appeal from the District Court of the United States for the Eastern District of New York

This cause came on to be heard on the transcript of record from the District Court of the United States for the Eastern District of New York, and was argued by counsel.

On Consideration Whereof, it is now hereby ordered, adjudged, and decreed that the decree of said District Court be and it hereby is reversed with costs and with directions to dismiss the bill.

It is further ordered that a Mandate issue to the said District Court in accordance with this decree.

Wm. Parkin, Clerk.

[fol. 453] [File endorsement omitted.]

[fol. 454] Clerk's certificate to foregoing transcript omitted in printing.

[fol. 455] Supreme Court of the United States

Order Allowing Certiorari—Filed November 8, 1937

The petition herein for a writ of certiorari to the United States Circuit Court of Appeals for the Second Circuit is granted. And it is further ordered that the duly certified copy of the transcript of the proceedings below which ac-

companied the petition shall be treated as though
response to such writ.

Endorsed on cover: File No. 41,934. U. S. Circuit
of Appeals, Second Circuit. Term No. 453. Genera
tric Company, petitioner, vs. Wabash Appliance Co
tion, Abe Adler and Abe M. Parker. Petition for
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